CROPS AGAINST THE WIND

On The Southern Great Plains

FARMERS' BULLETIN NO. 1833

U.S. DEPARTMENT OF AGRICULTURE

FOREWORD

The southern Great Plains, as considered in this bulletin, is a geographical region including portions of five States. These States are Kansas, Colorado, Oklahoma, Texas, and New Mexico.

After the preparation of the manuscript for this publication the area, known as Region 6 for administrative purposes, was increased to include the entire State of Kansas. However, the present bulletin deals only with the area suggested by the original boundaries as shown on the back cover page.

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Crops Against the Wind on the Southern Great Plains

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Soil Conservation Service, in Collaboration with Subject-Matter Specialists

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FIGURE 1.—Some of the cultivated land in the southern Plains should have remained in grass. But it was not the immense plow-up during and after the World War that caused such widespread havoc. Rather, it was the inappropriate and ill-adapted farming practices that were used following the destruction of grass.

Across the Dry Line

The Great Plains region of the United States comprises approximately 352,000,000 acres, or 550,000 square miles of land. It is larger than Germany, Italy, and Japan combined. Viewed on a map, this sprawling tableland presents an immense inverted triangle with the base on the Canadian border and the blunt apex extending across eastern New Mexico and the Panhandles of Texas and Oklahoma, to the Edwards Plateau in southwestern Texas.

Geographers and historians are not in entire accord in defining the eastern limit of the Plains. Some place it at the ninety-eighth meridian; others at the one-hundredth. The western limit is usually placed at the 5,000-foot contour line adjacent to the Rocky Mountains.

The area here considered is the southern Great Plains, one of the dustiest parts of the Plains since 1931; it lies within the boundary lines of Region 6 of the Soil Conservation Service. A map of it will be found on the back cover. The area contains over 150,000 square miles of land and is more than twice as large as New England. The southern borders of Wyoming and southwestern Nebraska define the northern limit of the area. The lower border is almost a stairstep line extending from the southwestern corner of Oklahoma, just below the cap rock (boundary between the High Plains and the Red Plains) in Texas, to the southeastern corner of New Mexico.

Travelers going westward from the Mississippi through Kansas and eastern Colorado toward the Rockies may not notice the slow, persistent tilt of the land. In the 410-mile journey from eastern Kansas to the Colorado line one is lifted from about 1,000 feet to about 4,000 feet above sea level. Westward the Plains floor rises to about 5,000 feet at the base of the Rockies.

The traveler may notice more difference in the vegetation than in the elevation. Rainfall tapers off not far beyond the Kansas-Missouri line. There it is about 38 inches. To the west it drops from 30 to 25 to 20 to 15 and in places to as little as 10 inches or less in a year. With this drop in rainfall the country changes in vegetation. The transition presents a spotty pattern, of course, but one finds tall grass on the humid prairies and short grass in the subhumid higher plains. Still farther west, and more particularly in the semiarid Southwest, one finds mesquite and desert types of grass.

Roughly, the ninety-eighth meridian marks the dividing line between humid and dry-land agriculture. "West of this meridian," wrote Russell Lord in Miscellaneous Publication 321, To Hold This Soil, "farming must be done with an anxious eye to the sky; and the first need is to save for use where it falls every drop of rain the heavens grant."

This dry line, strung in a zigzag pattern up and down the ninety-eighth meridian, probably has enforced adaptations in ideas and ways of living that have few parallels in history. Coming out of a humid forested region east of the Mississippi, the early cattlemen carried axes and long-barreled rifles. Some went as far as they could by boat. But this was not far, for boats are useless where there is no water, and axes are nearly useless where there are no trees.

In the early combats with the Plains Indian the white man was frequently at a disadvantage. Though both whites and reds fought principally from horseback, the long-barreled rifle the white man used was an awkward implement as compared with the 15 or 20 arrows carried by the Indians. Consequently, the six-shooter stands as the first adaptation of the plainsman to his new environment. Other adaptations, such as windmills and barbwire, followed quickly. Trappings of the cowboy, the sombrero, the scarf, the chaps, which many easterners look upon as fanciful, were designed to provide a measure of protection during the serious work of riding herd.

Pushing across the dry line, the first of the farmers following the cattlemen tried to farm on the Plains as they were accustomed to farm in the Middle West or farther east. Their adaptations though less picturesque were not to be denied. Unless by chance they struck seasons of plentiful rainfall, they found that corn and seed of eastern grasses did not thrive robustly in the short-grass country. Moreover, they found that dry-land farming required changes in method and infinite patience and that more land was required to sustain a family than they had been accustomed to think of as necessary back home.

Since 1932—particularly in 1934 and 1936—soil of the southern Plains has been moved by the wind out of proportion to anything previously known in American history. Coincident with the distress caused by duststorms and sand heaps there has been a tendency on the part of some to recall the myth of the Great American Desert; to claim that the Plains grass should never have been disturbed with the plow and that it should always have been a land of few people and many cattle.

Looking backward, from a 1939 perspective, it seems certain that some land in the southern Great Plains should never have been plowed. But it appears even more certain that the biggest mistake was not the immense plow-up but the inappropriate and ill-adapted farming practices that followed the destruction of grass (fig. 1).

This bulletin briefly traces the circumstances which have created the soil problems in the southern Great Plains and shows how the hand of man has

hastened present troubles. But it goes further and deals with the methods now being used to solve the problem on nature's own terms.

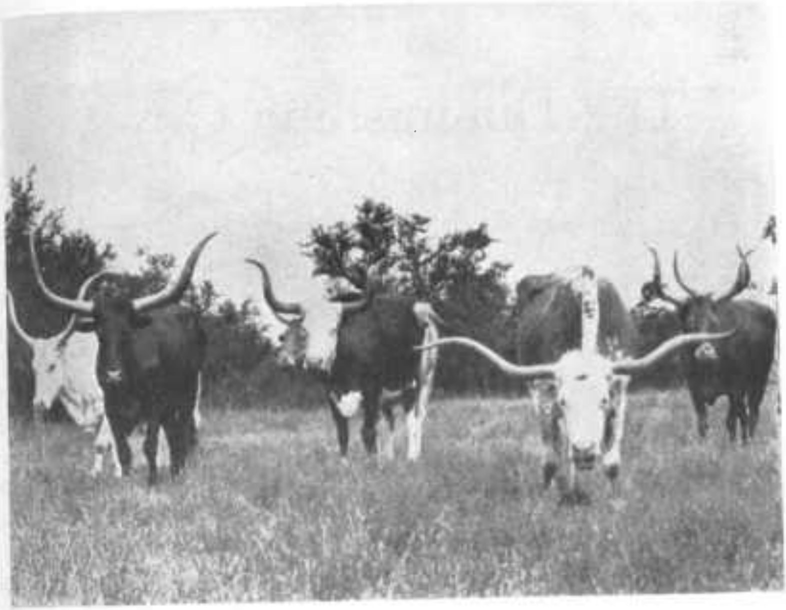

FIGURE 2.—Texas longhorns, in almost incredible numbers, were driven north over the great cattle trails across the Plains during the late sixties, the seventies, and the early eighties.

The Diminishing Cover

Plodding herds of tossing longhorns, driven northward across the Plains in the sixties, the seventies, and the early eighties, probably caused the first impairment of the native grass cover (fig. 2). But this impairment by trampling hooves was confined to a comparatively narrow strip of land around waterholes and along the well-worn cattle trails. Some grass was destroyed when settlers brought their plows. Still more grass was subjected to heavy use when the settlers' herds, in increasing numbers, were turned upon the range.

Then, as now, the damage to the range was caused principally by stocking beyond carrying capacity. But the relation of livestock numbers to the carrying capacity has been on a seesaw basis. Following several years of drought, livestock numbers usually dwindled. When these years of drought were followed by several years of plentiful rainfall, the grasses recovered and thickened. When forage improved, the number of livestock was increased to take advantage of increased forage and higher prices. When drought years struck again the ranges were overstocked, and prices were usually much lower. In this event rangemen were inclined to hold their animals, hoping either that prices might rise or that rains might fall. The net result is that overstocking has been most prevalent at times when the grass was least able to stand the abuse.

After the collapse of the cow rush a comparative peace and quiet rested on the Great Plains, except of course for the continuing conflict between cattlemen and sheepmen. The tide of settlers, though still active, was diminishing. In the transition period, barbwire, windmills, and plows, in large part were replacing the six-shooter, the lariat, and the branding iron. Old-time cattlemen and sheepmen were forced to higher, and for the most part rougher and drier country farther west. Success of the settlers in growing crops depended largely on the rainfall.

Shortly after the turn of the century the United States Department of Agriculture established dry-land field stations throughout the Plains. These stations were installed to determine the adaptability of crops and cropping practices to the climate, soil, and economic conditions of a dry-land farming country. Partly as a result of these tests and partly as a result of the experience of farmers who had lived through the vicissitudes of the Plains' environment, the agriculture was

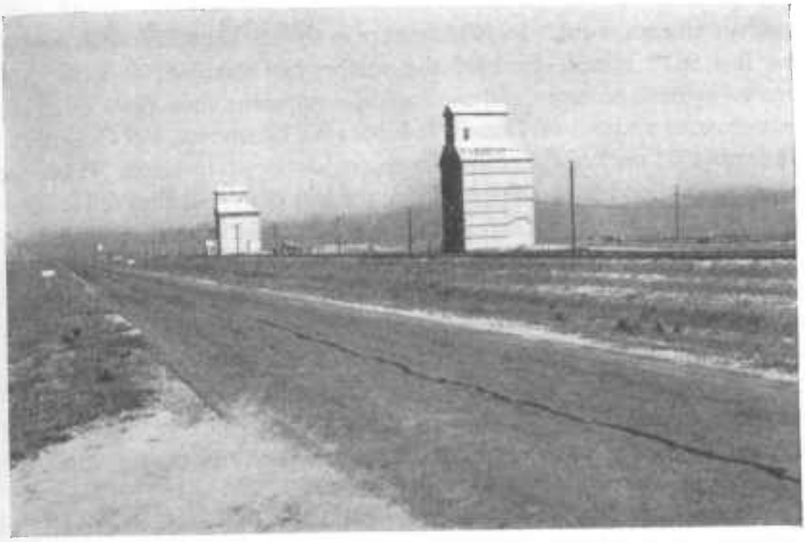

FIGURE 3.—Grain elevators followed the plows onto the Plains.

beginning to take on some aspects of permanence. There were comparatively few farmers who relied on wheat alone. Most of them grew feed crops for livestock and in addition raised their own horsepower for farming purposes. When dry years occurred many were able to retain their holdings and remain until more favorable years arrived.

But suddenly the World War changed all of this. Food would win the war. Prices rose, and rains fell. A new tide of pioneers went out on the High Plains and grew wheat. Thus began the greatest plow-up of grass land in American history (fig. 3). By 1924 the Plains States were growing about 17,000,000 more acres of wheat than they had grown in 1909. In the southern Great Plains the expansion in wheat acreage was greatest in those counties which cluster around the meeting point of the five States—Texas, Oklahoma, Kansas, Colorado, and New Mexico.

During the 5-year period 1910–15 farmers in Morton County, Kans., planted on an average 1,177 acres of wheat. During the 5-year period 1930–35 the average yearly acreage was 96,454. Grant County, in the 5-year period 1910–15, had an average yearly wheat acreage of 1,509. Twenty years later (1930–35) the average yearly acreage was increased to 140,626. Similarly, Hamilton County increased its average yearly acreage from 1,459 to 85,440; Seward from 39,250 to 144,762; Stanton from 502 to 152,353; and Stevens from 10,813 to 129,178. While the number of acres seeded to wheat soared abruptly between 1910 and 1930 the abandoned acres at harvesttime ranged from almost zero in the good years to almost complete abandonment when the rains failed.

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The extended plow-up, of course, was made possible only through the wide use of mechanical equipment. In 1925 farmers in the six Kansas counties mentioned above had 582 tractors. By 1930 the number had increased to 4,156. Similar increases in both acreages and mechanical equipment took place in all of the wheat-growing sections of Texas, New Mexico, Oklahoma, and Colorado.

The year 1931 marked the peak for both production and acreage. Prices ranged in the neighborhood of $2 a bushel during the war years, but they fell to below 25 cents in 1931. Though prices fell, there were forces at work that compelled men to keep on seeding extensive acreages. Caught in a web of debt, the farmer's only choice was to roll out the heavy artillery of production, break and seed as much land as possible, and hope for a crop that could be sold at a profitable price.

Less dramatic, less expansive, but not less intensive has been the cotton rush across the lower tip of the Plains in Texas. Cotton acreage is today expanding with a high-powered surge in western Texas and into the edge of New Mexico. Many virgin grass areas that were too far south to receive the full impact of the wheat plow-up are now being torn up for cotton.

The glamorous periods of western land taking, and grass destruction after settlement, are paralleled in scope and intensity by days in more recent years when wind-borne soil and dust reveal a story of land misuse. In the light of present knowledge the chief factors involved in misuse of land on the Plains are: (1) The farming of some land that should never have been disturbed by the plow, (2) inefficient use of the limited water supply, (3) ineffective crop management, and (4) lax business methods.

This land misuse, however, is no different from the land abuses practiced by ancestors of present-day easterners who cleared trees from the crests of humid slopes. Most of the westerners, a majority of whom were once easterners, embraced what they thought to be an opportunity on the broad, flat, and inviting acres of the Plains. Having had the opportunity to wreck grass—nature's protective mantle of vegetation—they did it under compulsions that are thoroughly American. And having occupied the land but recently, they had the advantage of using instruments that were perfected to the speed and acceleration of the twentieth century.

The Soil Moves

Ever since there has been a body of land on this planet soil has been moved by wind. Showers of volcanic ash and local sandstorms have long been recorded. But winds which pick up and carry the finest part of a soil from one State to another or out to sea are recent phenomena, reaching dimensions for which there are few known precedents throughout the world (fig. 4).

Digging into the oldest newspaper files now available on the Plains, Ewing Jones, of the Soil Conservation Service, found frequent mention of local duststorms in the latter part of the nineteenth century. Less frequently, he found reports which indicated storms of greater magnitude, but all were minor as compared with storms since 1932. That year, for the first time, most of the United States Weather Bureau stations on the Plains began to record the frequency, intensity, and duration of duststorms as a routine practice.

Erosion is a natural process. Under natural conditions nature establishes, with vegetation, a working balance between the rates of soil formation and soil removal. Crossing the Plains with animals, tractors, and plows, men upset the delicate hair-trigger balance between the climate and the grass cover which had held the soil for centuries. In many regions of plentiful rainfall this balance has been disturbed by the hand of man with ax, plow, and herds, as is proved by the deeply etched gullies and raw, eroded slopes of northern Missouri, southern Iowa, and other places. But in regions of scant rainfall, like the Great Plains, this balance of nature has been more dramatically disturbed, and the conflict between natural forces and inappropriate human enterprise is recorded in a marked transformation.

Damage

A reconnaissance survey by the Soil Conservation Service was made in 20 counties of Texas, Oklahoma, Kansas, and Colorado after the severe blows in 1937. The report, compiled by Arthur H. Joel, revealed that about 80 percent of the whole area may be considered affected to a variable degree by wind-erosion damage of one type or another and about 40 percent of the area by wind erosion to a serious degree.

In the region as a whole, comprising about 97,000,000 acres, wind-erosion

FIGURE 4.—A duststorm such as this is a comparatively recent phenomenon on the Plains.

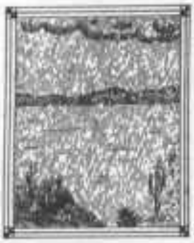
FIGURE 5.—The most troublesome result of wind erosion is the removal and accumulation of soil that has traveled but a short distance.

damage is not nearly so serious. However, serious damage has occurred in numerous smaller areas throughout the region. Serious water erosion has occurred on only about 4 percent of the area surveyed.

While the finer soil particles, in the form of dust, may be lifted high in the atmosphere, and carried hundreds of miles from their source, the most troublesome aspect of wind erosion is the removal and accumulation of soil that has traveled but a short distance (fig. 5). The degree of accumulation and removal depends upon the severity of the wind and the vulnerability of the soil. A light sandy soil which is devoid of vegetal cover and depleted of plant residues, may pile up in dunelike formations and attain heights of more than 20 feet through repeated attacks by the wind. Far more frequently the accumulated drifts are less than 4 feet in height. These are commonly referred to as hummocks.

But soil particles traveling through the air as dust, where all may see, form a dramatic spectacle out of proportion to the much larger volume of moving soil that hugs the ground. To our land body as a whole, the wind-erosion damage as evidenced by dust, dunes, or hummocks, is of much less importance than the damage caused by water erosion in the more humid and rolling sections of the country.

Climate, Soil, and Man



The southern Great Plains has certain characteristics in common with the Plains as a whole. It is a treeless region of light rainfall, high winds, high summer temperatures, and many sandy as well as fine-grained soils that blow and drift if they are not held on the earth by vegetation or other protective devices.

In most agricultural areas of the United States the rainfall averages 30 inches or more a year, but Plains agriculture must survive on an average of less than 20 inches. Yet this low rainfall is sufficient for a profitable agriculture if it is properly conserved and man selects the crops and systems of operation which will make the best use of it. It is not the low average of rainfall or the general deficiency that is of most importance. Of supreme importance are the marked variations which occur within the year and within a series of years. These fluctuations, while perhaps no greater than in most other parts of the United States, are more destructive on the Plains, for the rainfall usually hovers around the critical minimum for crop production.

Dodge City, Kans., lies on the northeastern edge of the southern Great Plains. Rainfall records at Dodge City date from 1875. Taken as consecutive 10-year periods, the years from 1875 to 1884 show the heaviest average rainfall, 21.14 inches. The lowest average rainfall in 10 consecutive years was 18.73 inches for the period 1885–94. Broken down into consecutive 5-year periods, the years 1880–84, with 24.80 inches, had the highest average rainfall; the lowest was 17.28 inches for 1910–14, which is only 69 percent as much rainfall as in these most humid years. The driest years were 1893 and 1910, when only 10.12 inches fell, and the wettest 1881, with 33.55 inches.

One hundred and eighty miles southwest of Dodge City, in drier north Texas, continuous weather readings have been recorded at Dalhart since 1908. The average annual precipitation for 30 years has been but little over 18 inches. The wettest year was 1923, when 33.4 inches fell, and the driest, 1934, when 9.78 inches fell. Since 1930 in only 1 year, 1932, has the rainfall been above the long-time average. During the 8 years prior to 1930 only 3 years had less than the long-time average.

Similar annual fluctuations in rainfall are found in records from other stations in the southern Great Plains. While the fluctuations in annual rainfall are extreme there is also a wide range of variability within an individual year. Normally, the

heaviest monthly rainfall in the Dalhart section comes during May, June, July, and August. But during 1923, a year with the heaviest rainfall on record (33.4 inches) the September rainfall was over 6 inches, at least three times the normal for that month. And during 1934, the driest year of record (9.78 inches), the September rainfall was considerably over the long-time average.

Rainfall occasionally comes in torrents. A single rain of an hour's duration may account for 20 percent or even more of the moisture for the entire year. Three inches of rain in an hour, when the year's total may be only 15 inches, or less, is clearly an unsatisfactory distribution of the season's rainfall. On the other hand, the rainfall of some years is characterized by frequent and ineffective showers. These showers, which are usually followed by bright sunshine, are no more effective, the plainsmen say, than trying to cool a hot stove with a few drops of water.

On the Plains, as elsewhere, much can be said about rainfall after the event, but unfortunately little can be said in forecasting what is likely to happen. Many folks believe in wet and dry cycles, and some serious students of weather records believe these cycles may exist. About all that can now be said is that wet periods and dry periods seem to appear in long, swinging cycles. And within these long swings of the cycle appear opposite cycles of shorter duration. Hence one cannot say that the appearance of a few wet years means that a prolonged drought has been broken. And neither can one say that the appearance of a few droughty years means an extended period of good years is at an end.

Some plainsmen believe in the 7-year-cycle theory. On this basis the drought which began in 1931 should have been broken in 1938. But the 7-year theory, or any other, in the light of present evidence does not hold. Tree-ring studies, which reach centuries back of the establishment of rain gages, reveal no consistent pattern. A wide growth ring indicates a season of plentiful rainfall, while the opposite is true for a dry year. Growth rings on ponderosa pine in Arizona suggest cycles of 14 and 21 years, with droughts of some severity each 50 years and major droughts every 150 years.

In the late sixties and early seventies the farmers' extended line of western advance gnawed with plows at the edge of the High Plains. Since abnormally heavy rains fell during this period many farmers formed the hopeful belief that an extended plow-up was making the country more humid. By 1880 some writers on the Plains declared that cultivation had increased rainfall. The fallacy of this belief is best revealed in the duststorms of the early thirties, which followed the greatest plow-up in history, during the twenties.

Wind

While the Plains farmer cannot predict when or how much rain will fall, he can be reasonably sure that the wind will blow with enough severity each spring through February, March, and April, to move unprotected soil. There may be severe blow periods at other times in the season, but the highest average wind

velocities occur during the late winter and spring months. During these period of high wind velocity, soil may be moved which otherwise might have remaineds in place under average wind pressure.

But soil movement is not the only ill effect caused by the wind. Wind, along with the high summer temperatures that are common to the area, accounts in part for the very high rate of evaporation in the southern Plains. And water losses through evaporation are higher during seasons of low rainfall than they are during years of heavier rainfall. As one goes north the rate of evaporation decreases; for this reason more rainfall is needed in the southern areas than in the northern to produce the same crops.

Soils

The soils over a large part of the Great Plains are derived from materials that came from the lofty mountain areas to the west. This water-transported material was deposited over extensive portions of the Plains. While many of the soils contain considerable organic matter, they generally are lighter in color than the soils of the prairies to the east, where the heavier rainfall favored a more luxuriant growth of native grasses.

Soils on the Plains are rich. Only in rare exceptions has there been any proved need for the addition of lime and commercial fertilizers to sustain crop production. The greatest limiting factor in crop production is the availability of soil moisture, not soil fertility.

While there is more uniformity in the soils of the Great Plains than in other equally large areas in the United States, there are still wide variations in their physical characteristics. The most conspicuous topographical variations occur along the breaks or the rougher country bordering streams like the Cimarron and Canadian Rivers.

The variations in texture, structure, and depth account, in the main, for the wide differences in the water-absorbing and water-holding capacity of the soils. Clay or clay loams provide a surface material of fine texture. These soils do not absorb water readily. If rains come in torrents, as they frequently do, much of the water is lost as run-off. If water once gets into these soils, they hold it well.

Sandy soils, on the other hand, absorb water readily, and it penetrates more deeply than in the finer-textured soils. Hence the ground-water supply is more readily replenished by percolation than it is in the tight or hard soils. It is difficult, however, on sandy soils to provide enough organic matter to bind the soil particles together in aggregates large enough to resist the wind.

Man can do nothing to change the climate, nothing to alter the natural topography of the land, or the basic materials from which the soil was derived. Man can, however, conduct farming operations which are in harmony with natural requirements. In the following discussion, which touches on controls and cures for soil erosion, these natural climatic and soil conditions must be kept in mind.

Water; Save It And Use It

Water is the key to the agriculture of the southern Great Plains (fig. 6). In a sense it is the beginning and the end of the regional agriculture. Water, when and where it is needed, is the supreme problem. Without water there can be no crops or pasture. Without crops or pasture there is no permanent protection for the soils against the prevailing high winds. And since agriculture is by far the most important industry on the Plains, the fortunes of the inhabitants rise and fall with the available supply of moisture in the soil.

All of this sounds disheartening and seems to indicate that opportunities occur only in the unpredictable years of plentiful rainfall. But it is not so hopeless as this. Up and down the Plains a few men have learned to make more efficient use of the water from the sky. Dry-farming practices focus on the simple object of conserving the scanty moisture supply. By exercising proved conservation methods one farmer may get as much benefit from a 2-inch rain as another, who has not employed conservation measures, gets from a 3-inch rain. That is, if a farmer permits an inch of rainfall to escape from his land as run-off he has lost an opportunity to moisten his soil at least a foot deeper. This extra foot of moisture frequently means the difference between a successful crop and a partial or complete failure.

In 1909, scientists at the Fort Hays Branch Experiment Station (Hays, Kans.), made the first observations to determine the relation, if any, between yields of winter wheat and soil moisture. In a modest paragraph on the first page of Kansas Bulletin 206, in 1915, the authors, L. E. Call and A. L. Hallsted, said: "As an average of 4 years (1910–13), the yield of grain secured was in direct proportion to the supply of available moisture in the soil at seeding time." Not until 1930 did Hallsted feel that the results were sufficiently conclusive to warrant generalization. Then he published his conclusions in a Preliminary Report of the Relations Between Yield of Winter Wheat and Moisture at Seeding Time, a paper appearing in the Journal of Agricultural Research.

In Kansas Bulletin No. 273, Soil Moisture and Winter Wheat (1936), the results of moisture determinations were given in relation to yields for the entire period up to and including the year 1934. This later report included findings at Colby and Garden City in addition to those of Fort Hays. Thus more than 25 years'

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results lie back of this work which was summarized in the Country Gentleman, March 1936, by R. I. Throckmorton, agronomist for the Kansas Agricultural Experiment Station. He said:

> * * * seeded in dry or nearly dry soil, the crop failed 71 per cent of the time, * * * seeded in soil with 1 foot of moisture the crop failed 34 percent of the time or about one chance out of three for failure.
>
> When moisture had penetrated to a depth of two feet at seeding time, there was only about one chance in seven of a crop failure * * * three chances out of five of obtaining a wheat yield of ten bushels or more per acre * * * three chances in ten of obtaining a yield of twenty bushels or more per acre.
>
> When the soil was wet to a depth of three feet or more, there was only one chance in ten of a crop failure and about six chances out of seven that the yield would be ten or more bushels per acre.

Any Plains farmer can now apply this test to his own wheatland with no more equipment than a yardstick and a spade. And the tests have been made on hundreds of wheat farms to determine their practicability. Yet despite the acceptance of the theory, many farmers seed wheat each fall in soil so dry that the crop is practically doomed to failure.

While the outstanding fact garnered in this long study is the relationship between moisture at seeding time and the yield of wheat, the various tests gave additional information on various cultural practices. For example, early preparation of the seedbed was effective in providing moisture sufficient to give a reasonable assurance of a crop two-thirds of the time at Hays. At Garden City and Colby, because of less precipitation between harvest and seeding, it was less effective, though it did increase yields materially at Garden City in years when the precipitation between harvest and seeding was above normal. Summer fallowing was always an assurance of ample moisture at Fort Hays, but at the

FIGURE 6.—Water is the key to the agricultural problem on the Plains.

other two stations it sometimes failed to store an adequate quantity of water. It was necessary to fallow the land at these stations to be sure of a crop equal to that assured by early cultivation at Fort Hays.

Summer fallowing a portion of the land with implements adapted to the purpose is a means of stabilizing crop production in much of the dry area. Its use should be confined to deep, moderately permeable soils, and a good job of fallowing must be done. Properly prepared fallow usually permits wheat to establish enough fall cover to reduce the hazard of erosion. Improperly maintained fallow, where weeds have been allowed to use a portion of the moisture, or fallow that has been maintained with tools that pulverized the surface may actually increase the wind-erosion hazard. The danger attendant upon unwise fallowing operations has made those believing in it most strongly a little hesitant in recommending its too wide application.

Among the more progressive farmers the fallow system has probably been more widely used as a conscious water-saving device than any other. But it is estimated that until very recently not more than 5 percent of the farmers have put it in operation. More recently, during the severe drought years and since benefit payments from the Agricultural Adjustment Administration began, perhaps as many as 20 to 30 percent have fallowed some of their land.

At the experiment station at Goodwell, Okla., on the flat border line of the two Panhandles (Texas and Oklahoma), H. H. Finnell made studies of yields of wheat in relation to moisture at seeding time and other factors. In 1933 he wrote:

> The observation of 60 crops of wheat grown at Goodwell, Okla., from 1924 to 1933 showed that a forecast of yields could be approximated by considering four conditions previous to or at the time of seeding fall sowing. They were July rainfall, fall moisture to a depth of 3 feet, amounts of available nitrogen in the soil, and amounts of unrotted vegetable matter in the soil.
>
> Favorable prospects for a crop were indicated, when the July rainfall was more than average, the soil moisture more than average, the available nitrogen less than average, and the unrotted vegetable matter less than average.
>
> Of the 60 crops observed, 6 started the season with 4 conditions favorable and made an average yield 30 bushels per acre. There were 16 crops with 3 conditions favorable and 1 unfavorable which averaged 20½ bushels per acre. Twenty cases with 2 conditions favorable and 2 unfavorable averaged nearly 10 bushels per acre. Eighteen crops beginning the wheat year with 3 or more conditions unfavorable averaged less than 2 bushels per acre.
>
> This experience would appear to indicate the dependence on a profitable yield was unsafe unless at least 3 of the advance conditions were favorable, and when July rainfall was plentiful even that could not be relied upon unless immediate cultivation were given to turn under the stubble and stop weed growth.

On a Soil Conservation Service project at Vega, Tex., soil-moisture tests and yields of wheat from 72 fields in 1937 support the findings of the experiment stations on the south Plains (fig. 7). On 6 fields that were dry at planting time there were 5 failures, and an average yield of 2 bushels on the other field. Of 14 fields having 12 inches or less of moisture at planting time 5 were failures, and 9 fields

yielded an average of 2.3 bushels per acre. On 28 fields having 12 to 24 inches of moist soil there were 6 failures, 15 fields averaging 3.5 bushels, and 7 fields averaging 7 bushels. Of 24 fields having moisture to a depth of 24 to 36 inches 2 were failures; 4 averaged 4.5 bushels; 10 averaged 7.8 bushels; 6 averaged 13 bushels; and 2 averaged 17.5 bushels.

It can be argued, of course, that factors other than soil moisture had some influence on the wide range of yields from these 72 fields. But it has been proved beyond a doubt that the chief cause of the differences lies in the variations of available moisture at seeding time. In the early spring of 1937 wheat looked promising on fields around Vega, if you except those that were seeded in dry or nearly dry soil. As late as March, even the Service men who had made the moisture tests could see no difference between the fields that started the wheat crop with 1 foot of moisture and those that had moisture readings down 3 feet. The young wheat grew rapidly, and it continued to grow through most of April. By May some fields suddenly ran out of moisture. Others ran out of moisture in early June. Still others held promise until almost harvest. That was the story of the wheat crop around Vega, and that has been the story in many places and in other years on the Plains.

This idea of the relation of yield to moisture at seeding time, cautiously mentioned by Call and Hallsted in 1915, is taking hold. On November 5, 1937, 120 grainmen, farmers, millers, and professors met at Topeka, Kans., to hear discussions of the latest developments in crop forecasting, weather cycles, and related subjects. H. L. Collins told the group that the Department of Agriculture now recognizes moisture tests in the regular crop-reporting routine. "Tests," he said, "showed that wheat seed beds this fall (1937) had less than half the moisture recorded a year ago, except in the few instances where land was summer fallowed." B. W. Snow, a commercial crop reporter, showed that a shortage of moisture had already placed odds against a normal crop. He added:

> The winter wheat crop is off the ground in June so that the cropped land is open for the storing up of the rainfall of July, August, and September for utilization in the germination and early growth of the new crop seeded in late September and early October. Practical experience agrees with scientific experiment that in this Plains territory the rainfall of the three months, July to September, received before the seed is planted, bears a close relation to the final crop yield of the next June. The subsoil or stored up moisture in the ground when the seed is sown has great weight as a determining factor in the crop yield nine months later; therefore a severe drouth in one year largely influences the wheat yield of the next.

On the broad expanse of the Texas plains are thousands of shallow depressions. Much water runs into these depressions, or wet-weather lakes, after heavy rains unless it is held on the uplands. Years ago, many bankers rode out through the country in the spring to appraise the security for proposed loans on the cotton crop. In general the more water they saw in these lakes the more money they were willing to lend. Calculating bankers today know that water in the lakes is run-off and that the surrounding land is deprived of that much water which

might have been stored in the soil. And, appraisers for the Farm Security Administration are recommending or rejecting applications for loans partly on the basis of soil moisture. Furthermore, some of the larger milling concerns keep men on the move up and down the Plains taking soil samples to determine moisture conditions so that they may better judge the prospects for a wheat crop.

Occasionally a farmer may succeed in producing a crop of wheat that has been seeded in dry soil. His success is probably due to unusual and extremely favorable moisture conditions during the fall, winter, and spring months. But the risk involved in seeding wheat when moisture is not already in the soil is too high to justify this procedure as a regular practice.

Crop failures are chiefly due to a lack of soil moisture, and numerous experiment station records emphasize the importance of conserving water on the Plains. But the slow acceptance of many of these measures can be explained in part through the failure, in an earlier day, of the widely heralded Campbell system of dry-land farming to fulfill the promises of its advocates. Following a string of dry years from 1890 to 1895 the idea of bridging over the dry seasons by storing moisture in the wet years was resurrected. The essential features of the Campbell system were attempted in isolated communities of the West as early as 1849. But Campbell electrified the entire West. The people talked of his system as if it were new. They said that it would save Plains agriculture. And the enthusiasm Campbell's ideas engendered did not stop at the edge of the Plains. By 1910 farm boys as far east as Ohio could be seen pulverizing the surface soil between tall rows of corn in the late summer months. A favorite method

Figure 7.—Yields of wheat on the Plains are usually closely related to the depth of moist soil at seeding time.

was to drive a horse hitched to a mowing machine wheel. The wheel was used as a drag. The idea, which came out of the West, was to maintain a mulch blanket of finely pulverized surface soil to retain moisture.

The Campbell theory, in the main, was that, if the soil was packed underneath and the surface stirred at the proper time, enough moisture would be stored to grow crops continuously. Many ideas seem to work well on the Plains if enough rain falls at the right time. The Campbell system seemed to work for a time, but dry years such as 1910–11 emphasized its draw-backs. Among the reasons now cited for its failure are: (1) Continuous cropping quickly depleted the organic material in the topsoil, leaving nothing to bind the soil particles together; (2) frequent shallow cultivation of the surface made the soil an easy prey to whisking winds; (3) much rainfall was lost as run-off because the soil could not absorb water from the torrential downpours characteristic of the Plains.

By 1915 the enthusiasm for the Campbell theory was definitely on the wane. But in the meantime, manufacturers had developed and widely distributed implements to meet the requirements of the Campbell system. These requirements called for rollers, subsurface packers, disks, and other tools which were designed to level, pulverize, and powder the surface soil. In more recent years there has been a retreat from this type of tool to those which dig deep, raise big clods, and leave crop residues on the surface. These newer implements prepare the soil in low earth dams for its own defense. Big clods, which most Plains farmers had been taught to break, can be raised most readily if implements are used when the soil is moist. They form innumerable ramparts which check wind currents and trap soil particles that are on the loose when the winds blow severely. When the rains come, particularly the driving, torrential types, these same earth dams serve as impediments to running water, thus permitting it to soak into the soil.

On deep sandy soils, which absorb water readily and deeply, perhaps the earth dams are not so important as water detainers. But sandy soils are most easily moved by the wind. So regardless of the kind of soil the Plains farmer has, be it sandy, taking water quickly, or "hard" (heavy), taking water slowly, the choppy surface is good insurance against soil movement and affords opportunity to store moisture to support a vegetal cover.

Implements

For the dual objective of providing barriers against the wind and at the same time making trenches to trap water, the lister, particularly the newer models which dig deeply and thrust up big clods, is a good tool. This lister plow, called a middlebuster in parts of the South, scoops out a trench and thrusts up sharp ridges on both sides rather than molding a furrow slice on one side. If the soil is so loose and dry that the lister cannot reach moist soil and thus raise large

clods, the chisel does better. The basin lister, of various mechanical designs, leaves cross dams of soil at intervals across the lister furrows. Water, after a rain, is detained in these machine-made earth enclosures to gain time for absorption into the soil. Another machine, the hole digger, leaves pits in the soil at intervals across the field.

There are still other tools now in use, such as the duckfoot and the rod weeder, which represent a conscious switch from the rollers, pulverizers, and subsurface packers of an earlier day to the deeper-thrusting tools of the present.

All of these more recent inventions represent progress in adapting tools for use on the Plains soil. But it is generally agreed that there are only a few farmers who need to purchase tools of a different type than they now have on the farm to obtain results in conserving moisture and in placing clod and furrow barriers against the wind. Even the one-way plow, a tool at first widely accepted and then just as widely rejected, is useful if used properly. In the preparation of soil for a crop in the early part of a season, particularly if there is long stubble, most men on the Plains agree that no tool beats the one-way plow. But if it is used continuously throughout the summer to kill weeds on fallow land, it leaves the soil in an ideal condition to be moved by the wind.

Contour Farming

From the standpoint of moisture conservation most of the tillage tools on the Plains become more effective if farming operations are conducted on the contour (fig. 8). And this applies to such a tool as the basin lister which leaves frequent cross dams in the furrows. If the basin lister is not used on the contour there is a greater possibility of water concentrating to such an extent that it breaks over and cuts a channel down the slope. A series of furrows, large or small, on the contour will retain more water than an equal number of furrows of the same capacity that run up and down the slope. Water retained largely in the spots where it falls causes a more even distribution of moisture. Occasionally a field will be hummocky or otherwise of such topography that it is impossible to have parallel tillage rows always run on the true contour. In this event the basin lister is more effective than a tool which leaves no cross dams.

Having the tillage rows of a field determined not by section lines or the compass but by the lay of the land marks the latest and greatest advance in water-conserving measures on the Plains. Outside of the demonstration areas of the Soil Conservation Service little contour cultivation could be seen in the southern Plains prior to the spring of 1936. That year, through governmental aid, more than 2,000,000 acres were listed on the contour. Following late May rains, a large number of moisture-penetration tests were made on contour-tilled land and on land adjacent which was level-tilled or untilled. These tests showed that about 1 inch of additional moisture was retained as a result of this listing on the

contour. Because of this extra inch of moisture, the soil on contoured areas was wet slightly more than 1 foot deeper than soil on areas that were not contoured. It has been estimated that this moisture increased plant growth to such an extent that approximately 500,000,000 pounds of additional protective residue was provided for the prevention of wind erosion on the 2,000,000 acres.

While there are still plenty of straight rows, the swerving contour lines of recent years present the greatest visual transformation since the plow-up of the late twenties.

FIGURE 8.—From the standpoint of moisture conservation most of the tillage tools on the Plains should be used on the contour.

Terraces

Of the various steps a Plains farmer may take in water-saving strategy for cropland, terracing may be considered as step No. 3 on soils adapted to their use. The first step, as outlined in the preceding paragraphs, is to use implements that roughen the surface, to trap soil that is propelled by the wind, and to provide innumerable pockets to detain water. The second step is to use all of the machinery on the contour, thereby stepping up or increasing the effectiveness of the low soil impediments in holding rainfall. Both practices should be used on both the sandy soils, which absorb water readily, and the hard types of soil, which absorb water slowly.

For the Plains farmer who has a hard type of soil, an additional step (No. 3) in the form of terraces may be used (fig. 9). The hard soils, being less permeable

than those with more sand, may permit some water to escape from a field even if proper tillage implements have been used on the contour. Again, terrace embankments are effective the year round, whereas the lower tillage ridges, on the contour, may be effective only part of the season.

On land adapted to their use, and this means practically all of the cultivated land in Region 6 with the possible exception of the deep sandy types, terraces have proved their worth. Their use in helping to store moisture in the soil for winter wheat has been abundantly proved. Likewise their value in storing moisture

FIGURE 9.—Terraces help to spread and hold water on thirsty fields.

for the benefit of sorghum, though not so widely tested, is convincingly shown in yields from 48 fields in the Dalhart section in 1937. These fields received an average of 13.26 inches of rainfall. On 20 terraced fields (4,226 acres) the average yield per acre of headed grain sorghums was 723 pounds. On 21 fields (4,035 acres) farmed on the contour but not terraced, the average yield per acre was 589 pounds. On 7 fields (882 acres) where crops were planted in straight rows regardless of slope an average of 461 pounds per acre was produced.

These tests show an increased yield on terraced land over yields from straight-row farming of 262 pounds per acre, or 56 percent, and an increase of 128 pounds, or 27 percent, in the use of contour farming over straight rows. It is obvious that some water was held by terraces that could not have been held by contouring alone.

The observations at Dalhart show that all the soils, except the deep sandy types, lost large quantities of water, even though farmed on the contour. In

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contrast the terraced fields held and absorbed all the rainfall, and in numerous instances caught and held floodwater from adjacent areas to augment the rainfall on the field. Except on the sandy soils, fields planted in straight rows were conspicuous for the spotted condition of their crops. In low spots the crops were good, but on the high points and slopes they had practically failed. This left the high points where vegetation was sparse without sufficient protection from the wind. In contrast, the crops on terraced fields were conspicuously uniform, giving a much higher grain yield for the entire field and at the same time providing an even distribution of stalks for protection against wind erosion.

Through the years, as terracing swung westward across the South toward a drier climate and a more expansive type of agriculture, the structures have taken on many adaptations. One of the first adaptations was to give more emphasis to terraces as water-saving structures and less emphasis to them as water-disposal structures. This transition and development can be traced from the humid Southeast, where rainfall approaches an annual average of 40 inches, to the high Plains, where it is less than 20 inches.

But of still greater influence on terrace design has been the conscious effort to adapt terraces to a more spacious agriculture that is symbolized by large farm machinery. Here again conceptions in adaptation can be traced from the one-mule, one-furrow type of agriculture, on rolling hills of the Southeast, to the wide, sweeping, and comparatively flat wheatfields and cottonfields of the southern Plains.

Since there is a wide difference in the tillage and harvesting methods for row

FIGURE 10.—The spacious agriculture of the Plains requires large farm machinery. Modern terraces are adapted to this requirement.

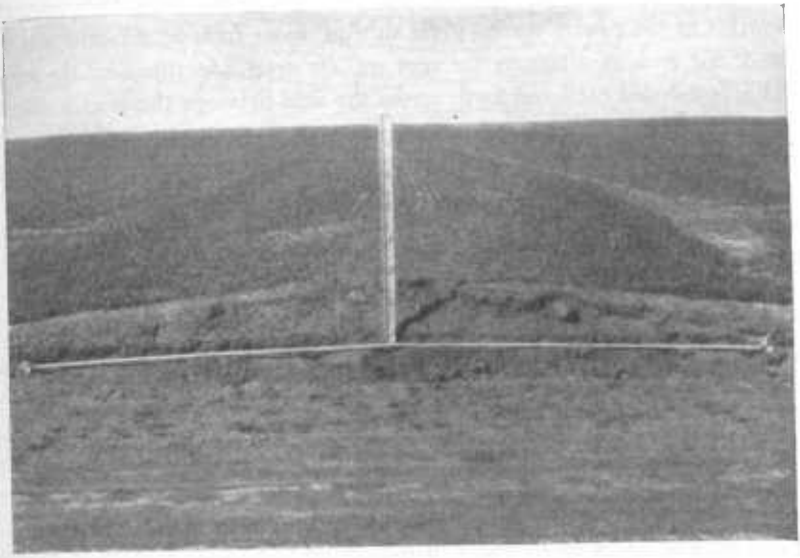

Figure 11.—A cross section of a wheatland terrace in western Kansas.

crops and for small grain, two types of terraces have been adapted to meet the more specific requirements. In the southern Plains these are designated as "wheatland" and "row-crop" terraces. Row crops and small grain are frequently alternated on the same land. The wheatland terrace would then be used even if row crops predominate, in order to facilitate the use of large planting and harvesting machinery. If row crops are grown exclusively in a particular area, the row-crop terrace would be used.

Wheatland terraces, in keeping with the size and convenience of using large machinery, have a maximum settled height of 18 inches and an average height of 12 to 15 inches (fig. 10). Frequently enough water-impounding capacity can be obtained with terraces less than 1 foot high. The base, in turn, is 40 feet wide for every foot of height.

Row-crop terraces are now being built with a settled height of not more than 24 inches, and the base is at least 40 feet if the height is 16 inches or over.

While the two types of terraces, wheatland and row-crop, are the most prevalent on the Plains, there are areas in which certain modifications have been made. In the rolling foothills where the Plains floor is broken along the edge of the Rockies, the row-crop terrace has been modified in harmony with the steeper slopes. This terrace is from 15 to 20 feet wide at the base and is either seeded to or sodded with some permanent type of vegetation.

The typical Plains terrace (fig. 11) is built on the level and has closed or partly closed ends, for the majority of the slopes are much less than 1 percent (1 foot fall in 100 feet). There are two exceptions to this general rule: (1) If the slope

exceeds 2½ percent the ends are left open, and provision is made for a controlled disposition of the run-off water; (2) if surplus water from an adjacent area is to be used, the ends of alternate terraces are left open. In this way the surplus water is marshaled back and forth across the field between the terrace ridges in sirup-pan fashion.

What should govern the spacings between terraces? The absorptive capacity of the soil is perhaps the chief factor to consider. On slopes of 1½ percent or less the general rule now is to space terraces 135 feet apart on clays, silty clay loams, and clay loams; 150 feet on silt loams and sandy clay loams, and 170 feet on sandy loams. No terraces are spaced less than 70 or more than 200 feet apart.

Always keeping in mind the large farm machinery of the Plains and the aversion that many farmers have to point rows, engineers grasp every opportunity to make the terraces as straight as practicable so that fewer point rows will be necessary.

To keep costs down, engineers build the terraces to hold the expected maximum rainfall in a 5-year period. If they built the terraces to hold the expected maximum rainfall for a 10- or 20-year period the costs of construction and maintenance would mount. On the Plains it now seems more practicable to repair a system of terraces once or twice in 10 years than to build them high enough to hold the maximum rain expected during that period.

Possibly the greatest objection the farmer finds to terracing is the inconvenience of farming point rows which occur when terraces are not exactly parallel. Figure 12 shows one method of working point rows which has been found practical on the Service demonstration areas. All rows are parallel with the nearest terrace or contour. The operator begins at the contour or terrace as at *A* and lays off the rows until he reaches the halfway point at the narrowest place as at *B*. He then goes to the contour or terrace at *C* and lays off rows until they meet the others laid off at *B*. He is now ready to lay in the point rows. He begins at *D* and plows the furrow marked No. 1 to point *E*. Here he makes a three-quarter turn and goes down the opposite side on furrow No. 2. He turns at the end and plows furrow No. 3 back to the point. This process is repeated until all rows are laid off.

In laying off rows from *F* to *G*, the operator begins at *F* and continues until furrows meet at *G* the narrowest point between the two terraces or contours. He then begins at *H* and lays off furrow No. 1 to the point at *I*. Here he makes a three-quarter turn and comes back on the opposite side, making furrow No. 2. On the opposite side he plows furrow No. 3 to point *K*. This process is continued until all point rows are laid off.

Another popular solution of the point-row problem is to sow or drill Sudan grass, or other close-sown crops, in the row-point areas.

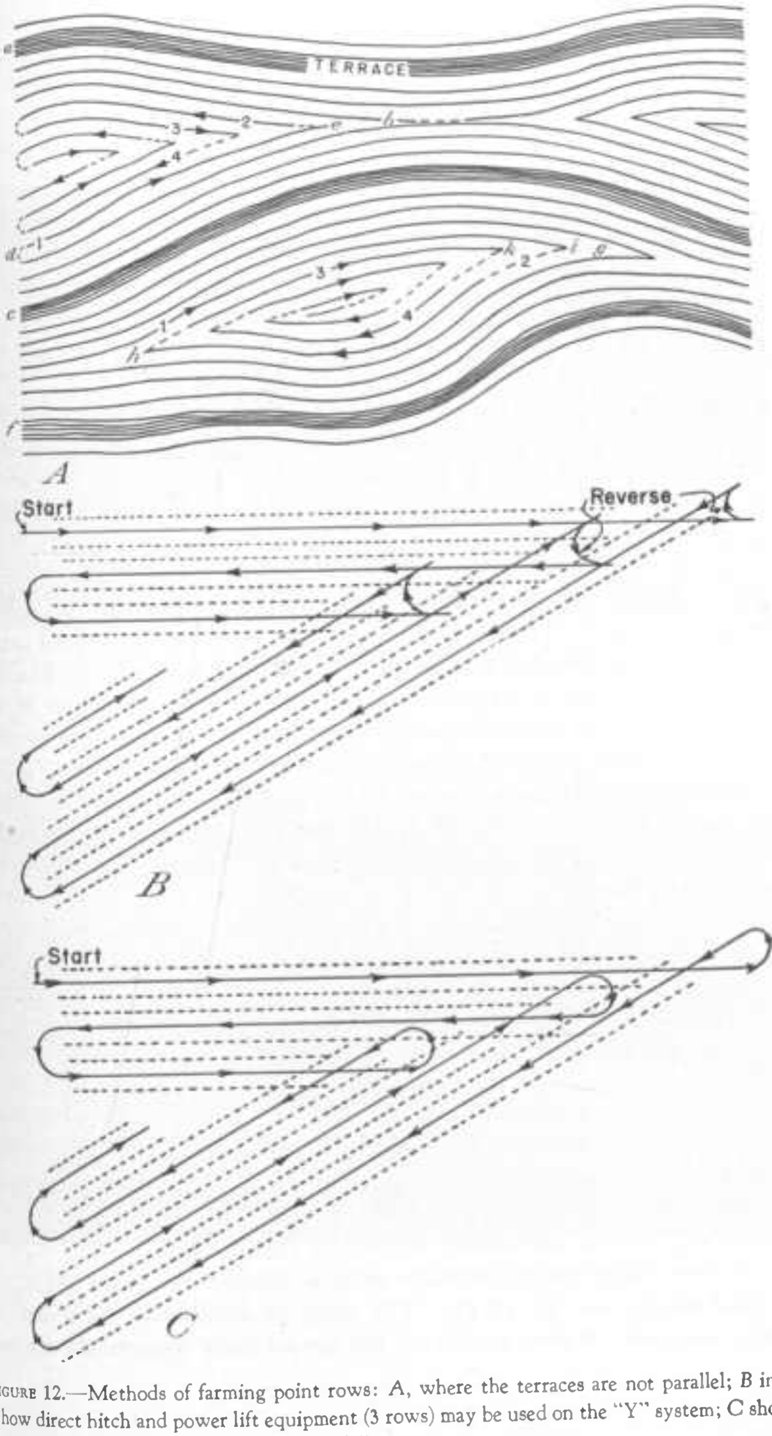

FIGURE 12.—Methods of farming point rows: *A*, where the terraces are not parallel; *B* indicates how direct hitch and power lift equipment (3 rows) may be used on the "Y" system; *C* shows the use of three-row equipment on the "circle" system.

Rain on the Range

Since 1931 few pastures in the southern Plains have escaped damage by overuse or by being covered, or partly covered, with blow dirt from adjoining areas. With the natural vegetal cover impaired or destroyed, much of the water needed for recovery of the grass has been lost as run-off. Two methods of retarding run-off are now being used successfully. One is to restrict grazing in proportion to the impaired capacity, and the other is to provide checks against run-off water and thus hold it on the field for the benefit of vegetation.

Both methods are recommended and are now being used because it seems impracticable to keep livestock off these pastures long enough for vegetation to return to its normal condition if unaided.

Two types of mechanical devices (both on the contour) are now being used to check run-off. One is a low earth ridge which concentrates water on its upper side; the other is a furrow or depression which catches run-off water from the area above, holding in place amounts up to the capacity of the furrows and spreading any excess. Though both types have been used separately and in combination during the last few years it is probably too early to determine definitely the advantage of one over the other. It does appear, however, that, in this area of low rainfall, vegetation will not grow well on the ridges. Some ridges have passed through two or three seasons and are not yet completely grassed over. In contrast, buffalo grass runners have joined across lister furrows in 30 to 60 days after a rain. Moreover, the ridges present a hazard in that they may break under heavy run-off concentrations during a localized rainfall of high intensity. And they require maintenance, which is not true of the furrow type of contour structure in which the furrow slice is broken and scattered. Hence, under most conditions the furrow type appears more promising than the ridge type at present.

The first of the pasture furrows on the Plains, many of which were constructed in 1935, were spaced from 20 to 40 feet apart. As observers compared the increased growth of grass on the various spacings they noted that the response was more favorable on the narrower spacings. And they also noted a better response in the shallower furrows than in the deeper ones. Consequently the most recently constructed furrows are spaced from 10 to 12 feet apart. Since the shallow furrow is preferable to the deeper types many of the farm tools of the Plains may be used successfully in treating pasture land.

The two-row lister, which provides furrows spaced 42 inches apart, has given good results (figs. 13 and 14). The wings or moldboards are sometimes clipped or removed. If they are left on, the furrow slices between the furrows

Figure 13.—Furrows on this Texas pasture were made in the spring of 1936 with a lister.

Figure 14.—A combination of listing and terracing in pasture furrowing.

are thrown together, and the resulting ridge smothers grass and is very slowly revegetated on most soils. While furrows of various capacities are under trial, observations indicate that 12 inches is the maximum width and 5 inches the maximum depth of furrow to obtain the best increase in vegetation the first year.

The three-row lister, which provides furrows 84 inches apart, if the middle unit is removed, has also given good results. In some respects the 84-inch spacing is preferable to the 42-inch system. Less sod is disturbed, and the middle furrow slices cannot overlap. And, while it is desirable to remove the wings, it is less essential than with the 42-inch spacing.

The chisel has given good results. It forms furrows usually from 2 to 3 inches wide and 12 to 18 inches deep. Possibly the best results have been obtained on gentle slopes where blue grama and buffalo grass predominate.

The terracer is now being used with good results (fig. 15). It is adapted to the purpose by removing the blade and bolting two or three bull tongues onto the moldboard. The moldboard is held about 1 or 2 inches above the surface of the ground. The soil and sod lifted by the bull tongues is spread evenly and thinly over the area adjoining the small furrows.

While Service workers are not ready to say which of the various ways of conserving rainfall on range pastures are best, yet any type tried thus far has increased the vegetation under some conditions. A cooperator on the Service project at Cheyenne Wells, Colo., furrowed his pasture on April 22, 1937. From that date to October 31, a little over 6 months, less than 6 inches of rain fell on these furrows, and grasshoppers completely destroyed the first grass growth of that year. After the grasshoppers left and after late summer rains the second grass growth gave farmers and others an opportunity to make comparisons. On the furrowed areas the density of grass growth was 9.48 percent, and the weed density was 0.17 percent. On all unfurrowed areas within 100 yards the grass density was 4.8 percent and weed density 0.54 percent. On a yield-per-acre basis the furrowed pasture produced 425.3 pounds of air-dry grass, whereas an unfurrowed area yielded 212.9 pounds of air-dry grass per acre. The treatment cost 26 cents per acre.

In a moister spot near Hereford, west Texas, that year (1937) tests on a pasture gave similar results. During the last week in May and the first week in June almost 9 inches of rain fell on this pasture. Seventy-two hours after these rains stopped, the average penetration on the furrowed area was 42 inches, and that on an unfurrowed area nearby was but 18 inches. More rains (totaling over 7 inches) came during July, August, and September. Clippings were made on October 1 on both a furrowed and unfurrowed area. The yield on the furrowed area was 1,761 pounds of air-dry grass per acre as compared with 704 pounds on the unfurrowed area. The cost of the treatment was 25 cents per acre.

Where the Plains approaches the eastern edge of the Rockies there are innumerable pasture areas that can be supplied with water which originates on the higher elevations. Since it is impossible to use this water on the spot where it originates the problem is to spread it over the grassy and more level pasture areas on the lower elevations. To control this water effectively a master or diversion terrace is frequently constructed along the base of the escarpment. Openings of various kinds and designs are provided to discharge the water safely. The water is spread over the grass by methods that seem most appropriate for a given location. In some instances if the land is comparatively level pasture terraces are provided and the water is conducted back and forth between the embankments in sirup-pan fashion. More frequently the water is spread by using pasture furrows. When the furrow adjacent to the master terrace is filled, the water spills over the furrow wall evenly onto the grass below. The detention and spreading may occur with each furrow down the slope, particularly if a large quantity of water is discharged from the rough escarpment above.

FIGURE 15.—These corrugated furrows, 1 month old when the picture was taken, were made with a terracer.

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Crops, The First Defense

Even before the Campbell theory of dry-land agriculture electrified the Plains and promised crops by storing rainfall in the soil, Government scientists had begun experiments to test the adaptability of various crops for the Plains. Chief among the new crops tested were the various types of African-derived sorghums. For years these camels of the plant family have demonstrated their ability to take punishment in the form of drought (fig. 16). But it has only been in recent years that the sorghums, in a broad way, have had an opportunity to demonstrate their usefulness in protecting the soil. As long as there was sufficient organic matter in the soil partially to offset the effect of the limited supply of rainfall during drought years so that wheat could be raised, few farmers paid much attention to any crop which they thought to be less remunerative. With the humus supply depleted and with repeated failures of wheat to afford cover for the land the sorghums have taken on an increased importance as a crop barrier against the wind.

Derived from a dry country, as are most sorghums, they demand little rainfall, whether they are grown for grain or for fodder. And while they respond to generous rainfall and the yields are in proportion, in drought years they will frequently produce a partial crop for feed and cover, whereas wheat would wither and die.

Grain crops of sorghum have grown with as little as 10 inches of rain in a year. With a more liberal supply of moisture grain yields may go above 60 bushels per acre. Moreover in favorable years, the grain, which almost equals corn in nutritive value, may be produced for approximately 20 cents a bushel.

After harvest, the numerous grasping fibrous roots decay very slowly; much slower than the roots of corn (fig. 17). And if a high stubble is left in the harvesting operation the roots will hold the stubble erect to check wind velocities.

The innumerable new strains and groups of sorghum under development in the high, dry country go by many names: Sudan grass, kafir, sorgo, and milo. The forage varieties are generally grouped as sorgo and the grain producers as milo or kafir.

More than 80 varieties are now grown commercially in the United States, and they thrive best in the Plains States. All have been developed as genetic adapta-

Figure 16.—The sorghums have demonstrated their usefulness on the Plains.

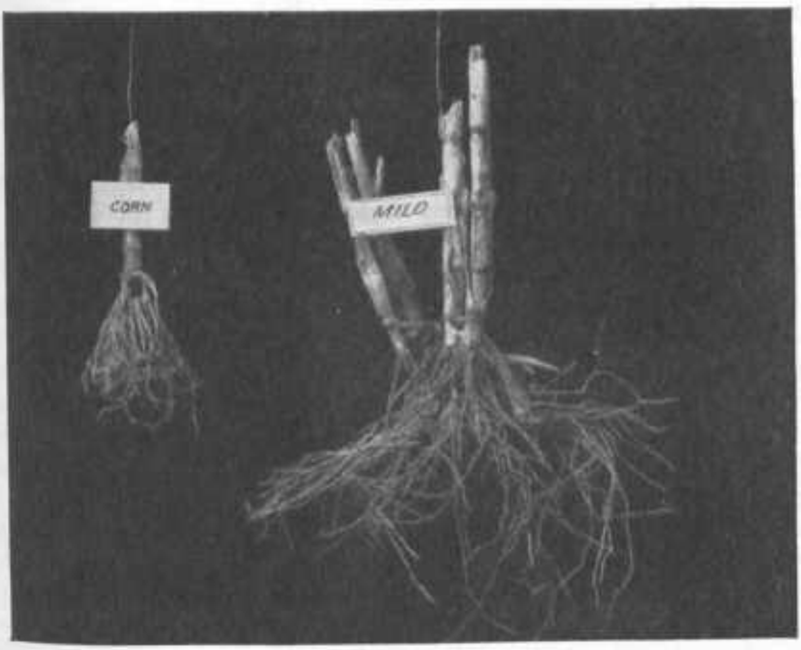

Figure 17.—Since sorghum roots are long and numerous and decay very slowly as compared with those of corn, they hold the stubble erect against the wind.

tions from the few varieties originally imported. Exceptionally given to mutations, the sorghums have been hybridized and otherwise adapted to conditions on the Plains. Plant breeders have evolved short plants like the Dwarf Yellow, Double Dwarf Yellow, Wheatland, and Beaver milo that fit the combine harvester. They have changed the color of seeds as in Sooner milo. They have adapted the plants to new environments as in Dawnkafir. They have introduced disease resistance, as in Spur feterita, and a dual-purpose plant as in Atlas sorgo.

By 1924 Colorado was growing 266,287 acres of sorghums; Kansas, 2,016,791; Oklahoma, 1,620,618; Texas, 2,572,037; and New Mexico, 289,578 acres. This totals over 5,000,000 acres in the five southern Plains States. If the present rate of increase holds, the acreage will be more than doubled by 1940.

Some experienced observers on the Plains believe that the sorghums, particularly the combine types, may, in time, enable the Plains to compete with the Corn Belt as a stock-feeding region. All of this looks to the future. But now there is no question about sorghums being able to hold soil against determined winds in a majority of seasons.

Sudan grass, a crop that is usually close-drilled, is perhaps the most useful among the sorghums for hay or summer pasture. In recent years it has been found especially useful in stabilizing hummocky soil and for border plantings.

Wheat, like sorghum, is a member of the grass family. It, too, holds the soil well against the wind. But inadequate moisture frequently limits the crop to such an extent that little or no cover is provided during the entire growing season. If the crop fails, as it frequently does, there is little or no protective residue left on the surface. Crop failure, more than price depression, rouses the ire of resident farmers against the "suitcase" operator, who sows his wheat in dust and leaves the land unanchored and ready to blow onto adjoining lands.

Cotton is a taprooted, erosion-inducing, heavy-feeding plant. In the humid Southeast cotton is said to be no more effective in preventing water erosion than a walking stick thrust in the ground. Against wind erosion cotton stalks offer more resistance than they do against running water. Because of the fact that the crop normally requires from three to five cultivations and cotton land usually goes through the winter without a cover crop, the land is left in condition to blow if not safeguarded by control measures (fig. 18). Moreover, in this region of low rainfall, the stalks are not tall, and they become dry and brittle before preparation is made for the next crop.

Except in one, or perhaps two, isolated areas, corn is not adapted to the high, dry portions of the southern Plains. Despite repeated failures, some corn is planted each year on the sandier soils. It fails under drought, but even if it survives in the more favorable years it produces practically one-third less grain than the sorghums do under similar conditions. Even though a crop can be produced occasionally, the roots of corn decay so quickly after harvest, in contrast to those

FIGURE 18.—Cotton stalks offer scant protection against wind and water erosion.

of sorghum, that the stubble is not held erect against the wind during the winter and spring months.

Beans probably should be placed at the bottom of the list of crops so far as their ability to hold soil is concerned. They are usually intertilled, which frequently leaves the surface soil in a loose and comparatively level condition. So long as the crop is growing it offers some protection; but after harvest, beware! The crop is frequently shaved or knifed off the ground in the harvesting process, leaving the soil loose and friable. Like those of other legumes, the plant roots decay and wither very rapidly, leaving the soil almost as loose as an ash heap.

Surrounding Safeguards

The water-saving methods heretofore discussed contribute directly to the surety of crop production. There are additional safeguards in the form of strip cropping, border plantings, cover crops, and others that may be used.

The term "strip cropping," as applied on project areas of the Soil Conservation Service, means the production of crops in long strips of variable width placed crosswise of the slope and approximately on the contour. The practice consists of alternating contour strips of densely growing soil-holding crops (small grains, sorghum, native grass) with strips of clean-cultivated crops (corn, beans, or cotton), or fallow (fig. 19). These close-growing strips, with their dense foliage above ground and their mat of roots below, will usually effectively check moving soil that is pushed by wind or carried by water from the adjacent cultivated or fallow strips.

FIGURE 19.—This Kansas field shows strips of wheat and summer fallow. The strips of wheat were summer-fallowed on the contour with a duckfoot cultivator in 1936. The summer-fallow strips were planted to grain sorghums in 1936 on terrace lines. The terraces were built during the winter 1936–37. The wheat yielded 18.8 bushels per acre in 1937.

FIGURE 20.—Strip cropping is in use under a wide variety of patterns. This field is strip-cropped with cotton and grain sorghum.

To date there is little experimental evidence to be used as a guide in determining the width and frequency of strips for any given field that is subject to run-off water and to wind erosion. Farmers on the Plains have used patterns which vary from alternative plantings of 2 rows of beans with 2 rows of sorghums to the use of 20 rows or less of sorghums with fallow spaces up to 200 feet (fig. 20).

While there is a lack of closely calculated experimental evidence about the desirable width of strips, observation of results on numerous fields in Service project areas form the basis for tentative conclusions. When cotton is grown on the lighter-textured soils, it is recommended that it be planted in strips of not over 30 rows in width. And these strips should be alternated with strips of sorghum that are not less than 15 rows in width. On heavier-textured soils, the cotton strips may be as much as 40 rows in width. Narrower strips of cotton are preferred if they can be adapted in a practical way to the farm program. When beans are grown, it is recommended that they be planted in strips 8 rows wide and alternated with strips of sorghum of not less than 8 rows in width.

On the lighter-textured soils of steeper slopes, where terraces have been constructed, many Plains farmers find it advisable to plant strips of densely growing sorghum crops in the point-row area which lies midway between the terraces (fig 21). This practice makes it easier to maintain the terraces at the proper height since the movement of the soil between the terraces has been checked. If terraces have been constructed but recently and the soil has not settled, some farmers seed the terrace ridge with some fibrous-rooted erosion-resisting crop. This supplies a form of strip cropping and protection to the terraces while they are settling (fig. 22).

Strip cropping is simple and can be applied on most farms without additional expense. The practice, however, should not be considered as a substitute for terraces on land adapted to their use. Occasionally there are farmers who expect to terrace their land, but facilities are not immediately available. In this event terrace lines are run on the field, and plowing is done parallel to these lines. Strips of densely growing feed crops, such as Sudan grass or grain sorghum, are planted on the area where the terraces are to be built. Corn, cotton, and beans are planted on the contour in alternate strips with these control crops. When the crops on the control strips are harvested, terraces may be built without disturbing the entire field area.

While strip cropping on the Plains has been more generally practiced in cotton-, corn-, and bean-producing areas it is becoming more popular where wheat and sorghums are produced, and summer fallow is more generally practiced.

A few farmers in the areas adapted to wheat and sorghum have adopted a method that is generally followed in the cotton section. This practice consists of roughening the land with a lister or chisel during January or February to

conserve moisture from the late winter or early spring rains. Incidentally this practice gives additional protection against wind and water erosion.

Some farmers on the Plains have found that they can control the soil on their own land and keep it from moving. But unprotected land around the borders may menace their own crops. In this event border strips have been found effective (fig. 23). Permanent solid borders of native grass or some other perennial soil-binding vegetation are preferred, although annual plantings may be made to form a solid cover. These border strips should be wide enough to provide turning space for farm implements.

While these border strips have proved effective on project areas of the Soil Conservation Service, they cannot be used indefinitely as protection against wind-blown soil from adjacent land. In time, the soil caught in these strips will form dikes. Border strips should be used pending the time when the soil on adjacent land is brought under control.

When winter wheat fails and the summer season is approached with the ground in a bare condition, a wide-row planting of sorghum is in order. Instead of fallowing the land, a dual-purpose (grain and forage) crop may be grown in single rows or double rows 10 to 15 feet apart. Weeds, during the summer months, are kept under control by cultivation, and the intervening spaces serve as a partial fallow. The rows of sorghum give stubble protection against moving soil until the newly seeded wheat has an opportunity to cover the ground. A wide-row planting of sorghum, however, should not be used unless there is a reasonable

Figure 21.—In the point-row area midway between terraces, and particularly on the lighter-textured soils of steeper slopes, some farmers plant strips of densely growing sorghum as shown above.

FIGURE 22.—To provide protection for the new terrace ridge while it is settling, some farmers plant the terraced area to a fibrous-rooted, erosion-resisting crop.

amount of crop residues remaining in the soil. If crop residues have completely disappeared a solid planting of sorghum should be made.

Cover crops may be used to good advantage in protecting the land during those periods of the year when the ground cover of the preceding crop has disappeared or become ineffective. Sweetclover, rye, oats, wheat, Sudan grass, and sorghum are crops that may be used in some areas. The crop should be planted just as soon as sufficient moisture is available. The crop should be planted and disposed of in order to provide erosion control and cause no interference with the next regular crop.

Crop Management

So far this discussion as it relates to wind-erosion control has been confined principally to (1) a discussion of methods to insure crop production through appropriate methods of saving water; (2) why some crops protect the soil better than others; and (3) the use of machinery in providing soil barriers against the wind.

The story now turns to crop management. And crop management means the management of grazing lands as well as cultivated land.

Possibly the first consideration should be given to the size of the operating unit. Unquestionably much soil damage has occurred on the Plains because the units were of a size that did not harmonize with the type of farming pursued. Sometimes the units have been too large, but more frequently they have been too

small. The cause for these small units can be laid principally to the provision in the various homestead laws.

Soil, climate, and market conditions are among the factors that determine the logical size of a land unit. In the typical cotton areas of the southern part of the Plains 160 acres is considered adequate to provide a reasonable standard of living for a farm family. On the typical wheatland 640 acres is believed to be necessary. On land that is adapted principally to grazing but where some wheat and feed crops are grown, the minimum probably should not be less than four sections (2,560 acres).

Nearly everyone is agreed that straight wheat farming has proved a failure on the wheatland portions of the Plains. But there is also substantial agreement that a neat cropping plan designating certain crops for specific fields years in advance cannot be applied to the Plains. A flexible system is required. A flexible system of cropping permits the operator to take advantage of soil-moisture and fertility conditions of the land at planting time. It is now recommended that a wheat crop be planted only when soil moisture and fertility conditions are favorable in order to insure profitable production and a covering of vegetation for the land.

In the case of wheat farming, it is recommended that wheat follow wheat only when moisture conditions make it practical. When winter wheat fails and the ground cover is insufficient to protect another seeding of wheat, a regular planting of sorghums should be made following the wheat failure. And wheat will only be planted following the sorghum crop when moisture conditions are favorable. Observations made in the spring of 1936 and 1937 indicate that on those areas where two or more crop failures and subsequent soil blowing have almost entirely destroyed or removed all organic residue, it is advisable to make solid plantings of sorghums to check erosion and rebuild the organic-matter content of the soil. Such solid plantings reduce the opportunity for a wheat crop that year by reducing the subsoil moisture.

Most agronomists and soil scientists believe that a grass crop should be included in any cropping system that is designed to protect existing soil values. But no adaptable grass for the southern Plains is now known that fits well into crop rotation. If such a grass is found—and a diligent search is being made—it will be included in the cropping recommendations. The first problem is to find the grass, and the second is to determine practical methods of establishing stands. But even when these problems are solved a flexible system of cropping must be pursued on cultivated land in order to obtain the maximum advantage of seasonal rainfall conditions.

The ability to do things at the right time is probably the major factor in determining the success or failure of a farm manager on the Plains. This is particularly true with reference to tillage and seeding operations. Work performed at the proper time may bring generous rewards. Work performed at the wrong

time may exact severe penalties. A farmer, for example, may have adequate equipment in the way of tillage and seeding implements. He may use the implements on the contour; he may have had his land terraced; and he may employ strip cropping or other modern methods of saving soil and water. But if his farming operations are not timely the best results cannot be obtained. To raise big clods for soil barriers the tillage work must be done when the soil is moist. Weeds, if not promptly destroyed, will sap enough moisture from a field to eliminate any possibility of a productive crop. A Russian thistle, it has been estimated, will use three times as much water as a sorghum plant; in other words, one-third of a stand of thistles will use as much water as a full stand of

FIGURE 23.—A roadside border strip of Sudan grass, as shown on the extreme right and adjacent to a highway, protects the crop strips at the left. Unprotected land lies to the right of the highway, in the background.

sorghums. Moreover, if a pasture is to be furrowed, the operation should be performed in the early spring in order to receive full advantage of the rains if they come.

Grazing Management

Though much sod has been broken for crops in the southern Plains the largest acreage is still in range or farm pasture. Of the 97,000,000 acres in Region 6, the area here considered, approximately 65,000,000 acres are in pasture. In view of this larger acreage devoted to grazing, the management of range lands in such a way as to perpetuate their usefulness demands attention.

Grazing must be restricted on denuded pastures to allow grass to become reestablished. This result is best attained by keeping livestock off except for a

possible light grazing in the fall after seed matures to allow it to be trampled into the ground. In the meantime livestock can be grazed on temporary pastures or provided with an extra supply of other feeds if provision has been made in advance.

When pasture grasses become fully established the goal sought is to maintain sufficient height and density of cover to prevent erosion. From the standpoint of cover it is recommended that short grasses be grazed not closer than 2 inches and the tall grasses not shorter than 4 to 6 inches from the crown during the growing season. An arbitrary system for grazing control cannot be determined in advance since the carrying capacity and grazing periods vary with seasonal conditions. Some successful stockmen believe that not over 20 to 30 head of livestock should be grazed on a section of fully established pasture land. Other successful stockmen keep an eye on the range by noting the time of day when the cattle lie down for rest. If the cattle, for example, have had their fill and are at rest by 10 a. m. the stockman concludes that the turf is in good condition. But if the cattle are milling and trailing around at 2 p. m. the stockman concludes that the vegetation is becoming short and that some of the livestock should be removed.

Much of the pasture on the range is damaged each year by turning livestock on grass too early in the spring. The sappy early grass is low in total nutrients, and grazing at this time encourages excessive trailing. Many good stockmen wait until there is enough top growth to give a cow a ready mouthful of grass before turning cattle in to graze. To provide grazing in the meantime a supplemental pasture such as winter wheat is frequently used.

Another range practice that has been found helpful is to defer grazing about every third year until late summer or early fall. This method allows plants to reseed and recover from the drain of continuous grazing.

Excessive trailing and trampling is always damaging to the turf on the range. If watering and salting facilities are well distributed this trailing can be reduced. Most stockmen concur in the opinion that livestock should not be forced to travel more than 1½ miles to reach water (fig. 24). In rough mountainous country the watering places should be closer. Proper distribution and frequent shifting of salting places will encourage even grazing and help to maintain a uniform vegetal cover.

During periods of scant native cover and drought the restoration and maintenance of permanent pastures can be facilitated by the use of supplemental pastures. Wheat and other small grains may be grazed during the winter and spring. Some stockmen and ranchers sow these crops to be used only for grazing in the early spring before stock is turned onto native pastures. This land can then be planted to a feed crop. Wheat that is to be harvested can be grazed to the point that will still permit it to mature. If wheatland is grazed while the soil is wet the hazard of soil blowing is reduced by puddling and the

Figure 24.—Most stockmen on the Plains concur in the opinion that livestock should not be forced to travel more than $1\frac{1}{2}$ miles for water. Note the stock tank in the middle background.

Figure 25.—Ponds on range lands, designed primarily to aid in the distribution of stock, provide the necessary water facilities for wildlife.

roughened surface. If wheatland is grazed when the soil is dry the hazard of soil blowing may be increased. Sudan grass can be used for supplemental pasture during the summer and fall. During the fall and winter the aftermath of hayfields, stubble and stalk fields may be grazed, but care should always be exercised to see that the cover left is sufficient to protect the soil against spring winds and rain.

Wildlife Plantings

On the Plains, as elsewhere, wildlife must have food, cover, and water, or die. Every step taken by the Plains farmer to protect his land against either water or wind erosion is of direct benefit to wildlife species. The conservation of water for the benefit of crops aids in providing widely distributed sources of food and cover. And the numerous stock ponds on range lands, designed primarily to aid in the distribution of stock, provide also the necessary watering facilities for wildlife (fig. 25).

Many stockmen feel that the area immediately above these ponds should be fenced and vegetated in order to reduce silting and trampling. If the area is vegetated with the needs of wildlife in mind, food may also be provided.

FIGURE 26.—This field of dunes appeared as shown above in 1936. Prior to 1931 the field was in native blue grama pasture. It was cultivated 3 years and then abandoned.

From Hummocks To Crops

The controls and cures for wind erosion, previously set forth, have been outlined under the assumption that the soil is in a workable condition and that only normal good-farming practices, which include the more recent soil- and water-saving measures, are necessary to hold the soil against the wind.

But let us suppose that sand dunes are growing and moving or that hummocks of soil from 2 to 4 feet in height make it impossible to farm in a normal manner. What can be done? Perhaps the experiments conducted on the sand dunes in the Dalhart, Tex., area provide the best suggestions for coping with the most extreme conditions.

Following severe soil movement in the early thirties, a field—a mile in length and a half-mile in width—was surveyed in 1936 (fig. 26). Fifty-seven sand dunes, ranging from 1 to 9 feet in height and averaging 161 feet in length and 113 feet in width, were found on the field. Subsoil between the dunes was hard and eroded to a depth of 10 to 12 inches.

Individuals who were assigned the task of stabilizing the dunes worked upon the simple theory that the winds which pile soil in dunes might be used as a force to redistribute soil over the area between the dunes. But the soil blown from the dunes, they reasoned, must be trapped when it is blown back to the lower elevations. And the soil traps must stop and absorb any water which falls.

In November the entire area, including the dunes, was solidly listed (42-inch rows) to a depth of 8 to 10 inches in an east-west direction or crosswise to the prevailing wind. These deep lister furrows turned up clods of sufficient size to provide protection against wind erosion from 1 to 3 years. In addition, the cloddy surface was ready to catch and hold the soil material which might be moved from the dunes.

In March 1937 it was estimated that approximately 60 percent of the soil material had been spread back over the field, and the dunes decreased in number from 57 to 29 (fig. 27). In June 1937 the field was planted to row crops, which included Sudan grass, kafir, Black Amber sorgo, millet, and broomcorn (fig. 28). The north and west borders were listed as a preventive measure against crop failure and wind erosion. By October a good cover crop was obtained over the

entire field in spite of limited rainfall that was 6 inches below normal. The best growth was on the eastern half of the area where the sand had redistributed itself to a greater extent. A comparison of the various species planted showed that broomcorn developed a better stand and produced a more vigorous growth under the different soil conditions. Sudan grass was second in importance, and Black Amber sorgo and kafir competitors for third place.

Prior to 1931 this field was clothed securely with blue grama, side-oats grama, and occasional patches of sand sage as the chief shrubby plant. It appeared no different from countless other fields in which the sod had never been disturbed with the plow. But in 1931 the field was broken and planted to a row crop. It was planted again in 1932 and in 1933, but owing to drought only one crop was harvested during the 3 years. Because of continued drought and crop failure the land lay idle after 1933 until work was started in 1936.

During 1935 and following severe soil blowing in 1934, magazine and newspaper writers visited the Dalhart dunes. Some of the same writers returned in 1937 to see the results of the work attempted in the meantime. They could not find the hilly mounds of sand that looked so menacing in 1935. Crops were growing. Even the soil technicians could not locate the spot occupied by the dunes except to point to boundary lines indicated by stakes.

While farmers and soil conservationists proudly describe "before and after" conditions on this field, and while they are now willing to tackle almost any dune if given a fair break with the weather, they are quick to admit that the

FIGURE 27.—The dune field (see fig. 26) was solidly listed in November 1936. In April 1937, when the above picture was taken, much of the soil material had been spread back over the land and caught in the lister rows. Note the bare area in the middle background which had been occupied by a dune.

Figure 28.—In June 1937 the field was planted to row crops, which included Sudan grass, kafir, Black Amber sorgo, millet, and broomcorn. The picture was taken in August.

most important job is to prevent land from getting into a condition that makes dune leveling necessary.

While dune leveling has perhaps been the most spectacular accomplishment in the worst blow spots, a far greater problem is to find practical methods of leveling the larger areas of hummocky land that once raised mile-square fields of bumper wheat in good years or failed even with sorghum in drought years.

A common method used to bring this hummocky land into workable condition is to drag a section of a railroad rail at right angles to the line of draft. Tractor-drawn terracers have been used also. Some farmers have had fair results in using a disk or a common drag harrow.

Regrassing the Worst Areas

"Put it back to grass" was a familiar theme on the Plains after the severe blow periods in the early thirties. Grass, it was said, once held this soil secure even through extended periods of drought. Some reached the conclusion that the soil could be stabilized only by a natural vegetal cover.

Most of the experienced observers on the Plains do not believe that any large proportion of the land now under cultivation, and suitable for cultivation, will be returned to grass in the immediate future. They usually point to two reasons. One is the difficulty of establishing a native grass cover; the other is the potentially high returns which can be expected from feed crops and wheat in comparison

with returns from grazing land if the cultivated land is farmed in an improved manner and full advantage is taken of water-saving measures.

But there are areas where effort should be made to get the land back under a cover of native grass. These areas, though less extensive than they were previously considered to be, are too vulnerable to the winds to justify their exposure through cultivation.

Early in the present century agronomists turned their attention to the introduction and experimentation of dry-land plants that might be used as a partial substitute for wheat and the improvement of wheat varieties. Only within the last 5 years have many agronomists on the Plains, as elsewhere, given serious consideration to the culture, management, and seed production of native grasses. New introductions of drought-resistant varieties, high in seed production and forage yields are also needed to increase returns from revegetated fields.

Successful effort in the reestablishment of native grasses has been spotty. For the most part rains have been subnormal, and agronomists believe that when not enough rain is received to grow the sorghums, which demand little rain, there is slight hope of getting grass to thrive.

Granting that adapted grass seed is available and that enough rain will fall, the preparation of land to be regrassed requires planning ahead at least a year. First of all the land to be seeded must be stabilized by planting a cover crop such as Sudan grass, cane, or millet preferably with a drill and on the contour. If planted in rows, this crop should be cultivated during the growing season and harvested to leave 8- to 12-inch stubble. The native seeds should be planted with a drill in this stubble the following spring or fall.

Various mixtures of adapted seed are under trial in the area. These mixtures include such species as blue grama, side-oats grama, western wheatgrass, wild-rye grasses, big and little bluestem, galleta grass, bromegrass, crested wheatgrass, and sand dropseed. The particular mixture used in a given locality depends upon climatic conditions and soil type. The usual seeding is between 8 and 14 pounds to an acre. By planting the seed with furrow drills better results have been obtained than by broadcasting by hand and harrowing or rolling the field afterward.

Still other methods of seeding are under trial. A good stand of grass was obtained on a farm in the Hereford, Tex., project area by scattering blue grama hay over a contour-listed field in July 1936. Heavy rains fell on the field in the fall, and the grass plants grew about an inch before frost.

Successful stands of bromegrass, crested wheatgrass, and western wheatgrass have been obtained on lands being returned to grass in Colorado. Bromegrass and crested wheatgrass are grown more successfully in areas above 5,000 feet. The initial trials in the use of these grasses have been so promising that some farmers cherish the hope that commercial seed production may replace corn and beans as cash crops.

If Crops Fail

When crops have failed so there is insufficient vegetal cover for the land; when the winds lift soil from the earth and eastern newspapers recall the myth of the Great American Desert, then many farmers hustle fuel and oil into their tractors and jolt out to the fields in pelting grit to throw up temporary barriers against the wind.

Most farmers probably prefer the lister for these urgent calls. The lister pushes higher ridges against the wind and leaves more capacious traps for moving soil than the shallower types of cultivators (fig. 29). But if the farmer thinks that the blow will not last long he may use his ordinary shovel cultivator from which all of the shovels have been removed except the two on the outside. This makes furrows from about 38 to 42 inches apart, is light of draft, and covers the ground cheaply and rapidly. These furrows, however, have little capacity for storing rain water.

If the land is dry and hard the wide-spaced one-way plow may be pressed into service. This tool, adapted for the emergency, is an ordinary one-way disk plow with each second or third disk removed.

The blow spots, which are frequently the higher elevations in a field, will receive first attention. Driving at right angles to the wind and dust, the Plains farmer will strip-treat the most vulnerable areas first.

These stopgap methods of soil protection should only be considered when all others have failed. Obviously it is expensive to run a tractor or use a team to provide emergency treatment for a field. What the forehanded farmers strive for, and many of them succeed in doing, is to have their fields so well protected with a cover of crops or of crop residues that emergency treatments are unnecessary. In other words they strive to use their time and implements in preparing the land for crops rather than to hold the soil in an emergency.

Whenever possible, the forward-looking farmer makes sure that the stubble-fields and stalk fields are not overgrazed or burned and the protective value of the crop residue thus reduced (fig. 30). Some of the worst examples of wind erosion on the Plains can be traced directly to these two destructive practices. Grazing rights on stalk fields are often sold. The one purchasing the right usually will leave his herd or flock on the field until the last scrap of vegetation has been consumed. Severe trampling of stubble or stalk fields may make an otherwise well-

FIGURE 29.—When crops have failed so there is insufficient vegetative cover for the land, emergency tillage will help, temporarily, to check soil movement.

FIGURE 30.—The burning of stalk fields and stubble fields reduces the protective value of crop residues.

anchored soil susceptible to damage. Grinding hoofs tend to pulverize a dry surface, making it ready to move with the first strong wind.

The practical arrangement would be to provide for a reserve feed supply, stored and at hand, making it unnecessary to turn animals into stalk fields or stubble fields. If it is absolutely necessary to pasture these fields the pasturing should be done under close supervision, and the animals should be removed before the ground cover is seriously jeopardized.

But there is still another method which excels emergency treatment after the strong winds begin their attack. When circumstances have made it necessary to graze stalk fields or stubble fields, many farmers give their fields a protective tillage treatment before the wind strikes. Doing the tillage in this way prior to the blow period enables the farmer to follow contour lines with his tillage implements and prepares his fields for either rain or wind. If rain comes he can be reasonably sure that his field will hold most of the water that falls. If the winds blow severely enough to move soil, he can be sure that his deep furrows will trap most of it before it moves far.

Centers of Demonstrations

Since 1934, the Soil Conservation Service and more than 1,500 farmers in the southern Great Plains have been cooperating in effecting demonstrations of water conservation and land use to control erosion. These demonstrations show methods which may be used to defend against erosion more than 956,000 acres of land. Twenty-six of these demonstrations are now under way at scattered points throughout the area. They provide a proving ground where farmers of the high dry country may see the practices in operation, learn their application, and judge their effectiveness on the land itself.

Each demonstration area was selected because of the representative nature of its land problems and their severity. First a physical inventory of the land within the area was made. Erosion conditions and the factors influencing erosion such as topography, soils, and land use were studied and mapped in detail. On individual farms where the operator became a cooperator with the Service the details related to the survey were determined to an even greater degree of refinement. On these farms a complete plan for a coordinated program of land treatment, involving the use of adaptable conservation measures for each parcel of land, was made.

Most of the demonstrations in these scattered areas were started in the fall of 1934 or the spring of 1935. Others were started as late as July 1936. By July 1938 over 5,500 miles of terraces had been constructed on 160,000 acres of land. Laid in a straight line, these water-conserving structures would reach from New York City to Reno, Nev., and back again. Strip cropping was in use on 81,000 acres. Such crops as corn, beans, and cotton (all erosion-permitting) were reduced by 31,612 acres, and the erosion-resisting crops, chiefly the sorghums, were increased by 24,790 acres. Grass has been returned to 17,375 acres. Pasture ridges and furrows have been built on 182,293 acres and controlled grazing is in effect on 535,809 acres. Over 900 earth-mound stock dams have been completed, and 62 springs have been developed to help spread grazing animals over the range.

In late January 1938, and after the first duststorms began to roll on the Plains, the headquarters staff of the Soil Conservation Service made an inventory of land within the demonstration areas to determine how much of it had sufficient cover to prevent soil movement in the spring. It was estimated that only 101,929

acres of the 956,573 acres in the 26 areas were without sufficient cover to prevent wind damage. In January 1937, a year earlier, 300,363 acres had been unprotected with a vegetal cover. Thus the cover on nearly 200,000 acres was improved in a year's time.

These estimates were made under the assumption that only the normal high winds would come during the blow season. But in January 1938 no one could anticipate the severity or intensity of the wind during the following spring. On April 6, 7, and 8, a record-breaking 60-hour northern wind, averaging over 30 miles an hour (and reaching peaks of nearly 70 miles an hour), lashed the central portion of the southern Plains with a fury unequaled since 1918. In this storm, sand and dust moved first and then a mixture of sand, dust, and snow. A man employed by the Rock Island Railroad said: "There was so much sand on the tracks that we couldn't use the snow plows and so much snow that we couldn't use the sand plows."

As a result of this storm some soil moved from fields that were assumed to be under sufficient cover. Yet in spite of this storm the soil on fields that had a protective mantle of vegetation moved but little in comparison with that on fields with meager or insufficient cover.

Now let us have a look at five such demonstration areas.

Smoky Hill River Area, Colo.

This 160,000-acre strip of the Plains tilts slightly eastward and forms a part of the headwaters of the Smoky Hill River, immediately west of the Colorado-Kansas line, in Cheyenne County.

Early cattlemen, with an eye for grass, pronounced this area one of the best on the Plains, but the gently undulating slopes proved too enticing for homesteaders and land speculators. Sand-beaten and otherwise well-weathered land-office signs in Cheyenne Wells and other nearby towns bear witness to the eagerness to break the range into farms two decades back. The abandoned homesteads and idle equipment on the land suggest that the cropping practices following the tear-up were ill-adapted.

And yet for all that surge of plows on the grassland, the area is still predominately in range. When project workers made the preliminary survey in the fall of 1936 they found that approximately four-fifths of the area had not been disturbed with the plow.

The majority of the soils in this area (classified as southern Brown plains) are developed on loess. Even moderate erosion exposes the parent material, which it is very difficult to stabilize under cultivation. Men once thought this soil was well-adapted to cultivation, and the belief was reinforced by the few bumper crops of wheat in favorable years. These few favorable crops hoisted land values, and many farmers acquired holdings too small to provide a living.

When the series of dry years came in the early thirties most of the farmers on these cramped holdings went under, and while going under they used the open range on a free-for-all basis. It was not really a free range but rather unfenced, abandoned land owned by absentee landlords, some of whom had never seen it.

But range lands suffered from still another misuse. It has been common practice in past years for outside herdsmen to ship or drive livestock into this area when grass and water were available. Usually the livestock remained until either the grass or the water was exhausted. In some instances water has even been shipped into the area when a little grass remained after the local water supply was consumed. In 1933 one operator drove 5,000 sheep into the area. He leased 160 acres but permitted the sheep to graze on approximately 10 sections of open range. When the water was exhausted in the draws an auxiliary supply was transported to the sheep in tank cars from outside the area. Local livestock men who had expected to use the range the following winter were forced to sell their livestock or buy feed.

This highly competitive use of the range, coupled with the effects of drought and erosion, resulted in destruction or impoverishment of much of the grass, thus favoring waste of rainfall, a further decline of cover, and increased erosion by water and wind. Forage surveys show that some land will not carry 10 cows to a section while occasional sections a few miles away may carry as many as 30 cows. This wide variation suggests differences in soil types, grazing management, and the deposition of drifting soil from adjacent cultivated areas.

Since the average rainfall for the 7 years 1930–36 barely exceeded 12 inches, the cultivated crops had largely failed. In estimating the soil-erosion damage on cultivated land the soil surveyors classified it on 10 percent of the area as very severe; on 30 percent as severe; on 50 percent as moderate; and on 10 percent as slight.

Under these depressing conditions for crops and grasses all but a few of the operators were forced off the land. Most of the nonresident owners, who hold at present about 80 percent of the land in the area, paid their taxes from other revenues or allowed them to go unpaid. Taxes, in many instances have been unpaid for as much as 6, 7, and 8 years. All of which indicates an acute need for a more stable type of agriculture, one based primarily on grass, livestock, and feed production.

Control measures, in the main, follow the pattern of surrounding safeguards set up in other projects on the southern Plains. To determine the adaptable crops and cropping practices, service workers drew upon the experience of local farmers and the results obtained at the nearby dry-land station at Akron, Colo., and others on the Plains. In general, cooperating wheat growers strip-crop their fields on a fallow-sorghum-wheat rotation basis. The fallow strips follow the sorghum, and the sorghum strips follow the wheat. Cooperating livestock farmers plant Sudan grass, corn, and milo on a strip-crop rotational basis. The edges of fields that are exposed to drifting soil from small unprotected areas are

provided with a border planting. Where large unprotected areas exist these hazards must be controlled before a satisfactory crop system can be carried on.

Apparently the immediate problem was to stabilize both cultivated and grazing lands and give every aid to reestablishing a grass cover on grazing lands. Here, as elsewhere on the Plains, every precaution must be taken to conserve and utilize rainfall. Yet in view of the much larger acreage in grazing land in proportion to the cultivated land, it seemed that, ultimately, the open range should be fenced for proper management. Conservationists agreed that little could be gained by sinking water into the soil to improve grass if livestock numbers were allowed to increase above the carrying capacity of the range and promptly destroy the grass again.

FIGURE 31.—One of the major needs in the Smoky Hill River area is more fences on the range.

One of the major problems in the area was to provide the remaining operators with enough fenced range land so that livestock returns would provide the bulk of the income (fig. 31). This procedure would make it unnecessary for the operator to cultivate large tracts of land each year and leave them vulnerable to wind if crops failed. Moreover the plan calls for the building up of feed reserves in good years to tide the livestock over the droughty periods when grass is sparse.

Here is the way the plan is set up for one man. The former owner, who failed to make a living on a half section, left the country. The new operator, who moved into the abandoned home, secured 5-year leases on 3 sections of land, making a total unit of 3½ sections. The three leased sections were fenced. The leases cost the operator nothing for the first 2 years and 8 cents an acre for the last 3 years. The grass on these three sections was so badly damaged by blow

dirt and drought that it was believed that there would be little or no grazing value for at least 2 years. In 1937, with less than 11 inches of rainfall on the pastures, which had beeen contour-furrowed, the grass made a heartening response. It is believed that with the return of normal rainfall (about 17 inches annually) the grass will thrive sufficiently to support a cow on from 20 to 25 acres and still leave a protective reserve. Until grass is restored, however, it is not expected that the grass will support more than one cow on 40 acres.

Cash crops are planned on but 160 acres of cultivated land. Feed crops, however, will be grown for annual supplemental needs and to establish as soon as possible a 2-year feed reserve. It is believed that in the future this 3½ sections of land will support 100 head of breeding cows.

The operator is starting with 25 beef cows, 6 dairy cows, and some chickens. This will be the foundation unit, but heifer stock will accumulate. The idea is to let the herd and grass increase together.

All of this detail has been included here since it is representative of the steps taken in establishing 18 similar fenced grazing units now in operation on this project area. Figure 32 shows the original farm unit and the present unit after the enlargement.

The farm operator spoken of in the preceding paragraphs lived in the community. Most of the owners of land which went into the 18 units lived outside the area. Letters had to be exchanged. These letters to bankers, insurance companies, trust companies, and school teachers, to name a few owners in distant places—proved a slow substitute for man-to-man negotiations on most demonstration areas. Some of the replies indicated that the owners thought their land was resting and that it would again grow lusty crops of wheat and grass when the rains returned. It took patient explanations to show that the land was not resting and that animals on the loose quickly grabbed any vegetation which emerged after an occasional rain.

In checking up on three seasons' work in this area the Service found that over 85,000 acres of the project had been placed under agreement for the application of soil- and water-conserving measures. Terraces had been built on 5,246 acres; strip cropping had been applied on 12,965 acres; contour tillage had been used on 17,643 acres; and approved crop rotations had been started on 22,718 acres. On range land, contour furrows had been constructed on 33,493 acres, and controlled grazing was in effect on 67,815 acres. If the 55 stock ponds could be assembled, figuratively, the combined acre-feet of storage would cover 236 acres.

Impressive as these figures may seem, perhaps the most significant advance in this area has been the reorganization of farming units. While water-saving measures have proved effective, when there was any water to save and technicians occasionally wish they had more rainfall to help bring back cover, yet withal they are apprehensive. Several years of normal rainfall, they argue, may start the plows again. And in that case, when the inevitable series of droughty seasons return the land will again be without cover.

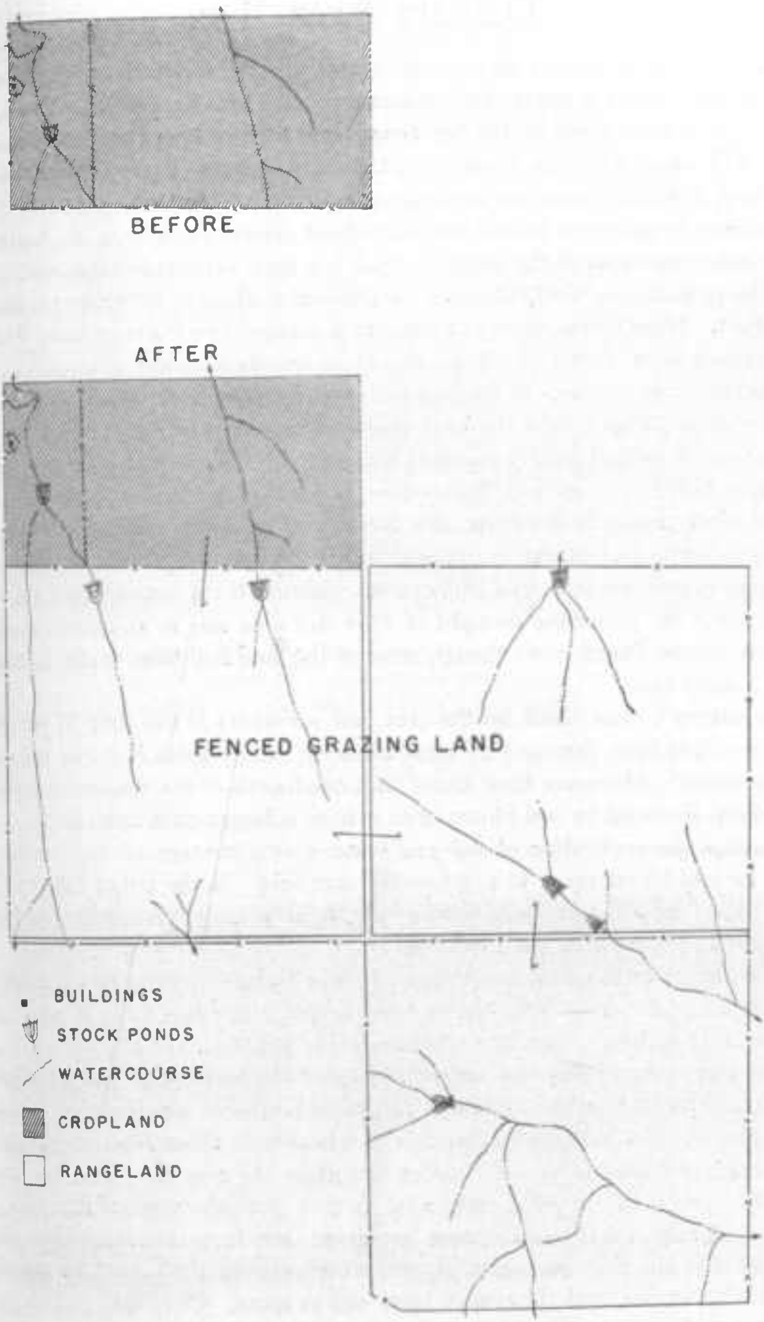

FIGURE 32.—One of 18 farm-unit enlargements in the Smoky Hill River project area.

Dalhart Area, Tex.

The first wind-erosion demonstration area selected for the southern Plains lies in Dallam County in the northwest corner of the Texas Panhandle. This county, along with nine others on the flat Texas-New Mexico line, was once included in the XIT ranch (Ten In Texas). In the early eighties Texas deeded this strip of land, 3,000,000 acres (an area almost as large as Connecticut), to an English syndicate in exchange for the erection of the present Statehouse in Austin. In the meantime most of the original ranch has been subdivided and sold.

The project area of 47,000 acres, established in August 1934, lies northeast of Dalhart. Ninety-five percent of the area is occupied by Pullman loam, Richfield fine sandy loam, Potter clay loam, and Pullman silty clay loam.

Agricultural practices in the past followed the pattern set throughout most of the southern Plains. At the time project activities were started wheat and a few row crops had largely replaced the palatable and nutritious native grasses such as buffalo and grama. Eighty-four percent of the land was in cultivation.

As elsewhere in this section, few farmers or stockmen realized that the continuous seeding of wheat in dry soil and destruction of stubble through overgrazing placed the land in a vulnerable condition to be attacked by the wind. Following the punishing drought of 1934 this area was in as critical condition as any on the Plains, even though most of the land had been under cultivation but a short time.

In making a close check on the area, soil surveyors found that 56 percent of the area had been damaged by wind erosion. Many fields had lost the soil to plow depth. Moreover they found that one-fourth of the remaining grassland had been damaged by soil blown onto it from adjacent cultivated fields.

Perhaps the application of soil- and water-saving strategy on this project can best be told by reference to a certain 600-acre field. In the fall of 1935 this field was filmed for a Government motion picture, The Plow That Broke the Plains, as a typical example of wind erosion.

The history of this field is not long. It was broken from native sod in the fall of 1929, just 6 years before the motion picture was taken. Good rains fell in 1929 (20.16 inches), and wheat was sown that fall (fig. 33).

The next year (1930) the owner harvested approximately 8,000 bushels of wheat. The good rains continued (25.26 inches), and another crop of wheat was planted. In 1931, 14,000 bushels of wheat were taken from the 600 acres. Although the rainfall was 10 inches less than the previous year, the stored moisture pushed forth a big yield, and another crop was planted that fall.

In 1932 only 1,600 bushels were harvested, but favorable rains came (20.09 inches), and the field was again planted to wheat. In 1933 rainfall dropped to almost 10 inches, and the wheat blew out in spots. Only 600 bushels were harvested that year. The land was summer-fallowed and again sown in wheat.

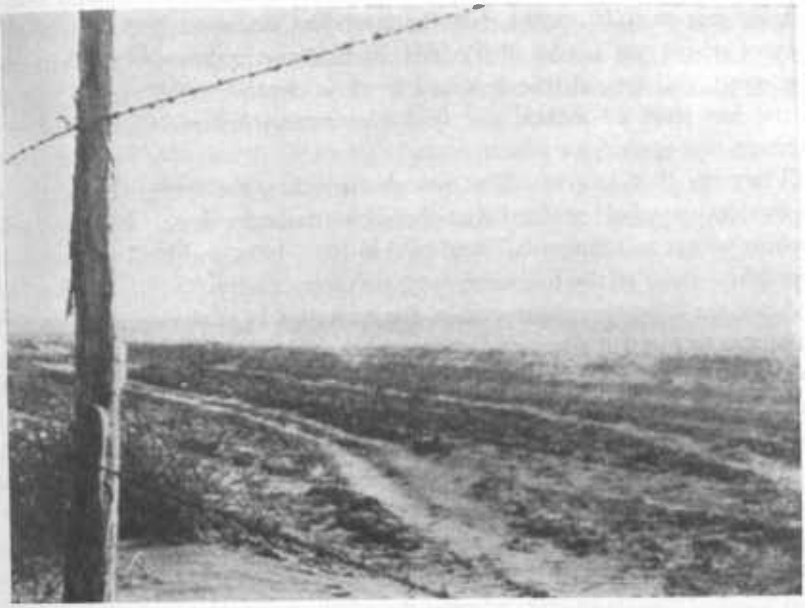

FIGURE 33.—This picture from The Plow That Broke the Plains shows the condition of a field in the Dalhart area in October 1935. Broken from native sod in the fall of 1929, this field produced three crops of wheat in succession and three failures in succession (see figs. 34 and 35).

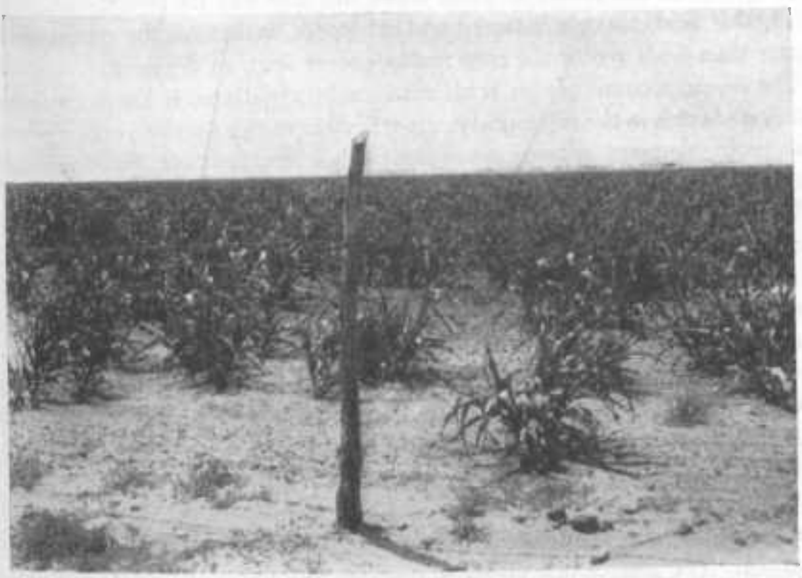

FIGURE 34.—The field above (the same as that shown in fig. 33) was terraced and contour-listed before the spring rains of 1936. It was planted solidly to milo and yielded 1,000 pounds of heads per acre. By October 1, when the picture was taken less than 9 inches of rain had fallen.

The spring winds of 1934 blew out the entire crop. The rains that year totaled less than 10 inches, but the land was summer-fallowed, and another crop of wheat was seeded in the fall. In 1935 the crop was again destroyed by the wind, and topsoil was removed to plow depth. With rainfall continuing to be less than 10 inches, the land was summer-fallowed, and still another attempt was made for a wheat crop.

When the 1936 crop of wheat was destroyed by the spring winds the owner of this 600-acre field realized that something must be done. His experience in seeding wheat on summer-fallowed land in 1933, 1934, and 1935 only to have the crop blow away in the following spring was too costly.

After the crop was destroyed in the spring of 1936 the east half of the 600 acres was terraced at a cost of $1.01 per acre. This land was then contour-listed so that if good spring rains came they could be caught and made to sink into the soil. Good rains came, and by June 1 the moisture penetration exceeded the root zone, but the rainfall for that year was but 9½ inches. The field was seeded to milo, and in the fall 1,000 pounds per acre of headed milo was harvested (fig. 34).

In 1937 terracing was completed on the west side of the field, and the entire field was contour-row farmed to grain sorghums. The average yield for the entire field was 964 pounds an acre, whereas the northwest quarter produced over 1,100 pounds an acre (fig. 35). The rainfall for 1937 was only 75 percent of the long-time average, and no appreciable amount of soil has been lost from the field since 1935. Even in the spring of 1938, when this area had the worst blizzard since 1918, this field, though battered and whipped, withstood the punishment far better than fields where the crop residues were scant or depleted.

The 8-year account of this field, with minor variations, is the story for many cultivated fields in the community. Not only have this field and others produced two profitable crops in years when rainfall has been deficient, but much organic matter has been restored.

When wheat fails, as it consistently has in the Dalhart area since 1932, most of the cooperating farmers grow solid plantings of sorghum in successive years until organic matter and crop residues have been fully replaced. When the organic matter is adequately replaced wheat may again be grown if the fall moisture is favorable. But some farmers wish to sow some wheat even before the land is fully brought under control. In this event, a system of strip cropping on the contour is used. Approximately half the field is planted in sorghum strips. The intervening strips are summer-fallowed. If summer and fall rains warrant, the fallow strips will be sown to wheat. If the wheat thrives, a good cover is assured for the fields. If wheat fails, the only method of control remaining is emergency tillage. The strips on which wheat has failed will then be planted to sorghum. The intervening strips of sorghum stubble may be either planted to sorghum again, or if residue is adequate, they may be summer-fallowed in prepara-

tion for fall wheat. If the rains are sufficient during the summer and fall, wheat can be drilled in the entire field. If rains are insufficient to justify wheat seeding, the sorghum stubble would provide the entire field with a good cover. If the entire field is in sorghum, wheat may be drilled in the sorghum stubble in the fall, provided sufficient fall moisture is available.

Yet, with all the safeguards which may be used in the production of wheat, the Dalhart project is essentially a feed-crop area. There is very little land well adapted to wheat in comparison with the area that is well adapted to the sorghums.

In the late twenties over half of the sandy soils of the Dalhart project area were planted to corn each year. In the early thirties, when the present series of dry years began, at least 4,000 acres of corn were planted. In 1935, 500 acres were grown; in 1936, 900; in 1937, 150; and in 1938, 50 acres.

The wheat acreage on the project dropped more slowly than the corn acreage in spite of continuous dry years and crop failures since 1931. In 1934, the year the project work started, 14,800 acres of wheat were seeded; in 1935, 12,210 acres; in 1937 less than 1,000 acres, not more than 10 acres of which were worth harvesting. Between 1934 and 1938 not one entire field of wheat has been harvested.

Coincident with the decline of wheat and corn acreage has been the increase in acreage devoted to sorghums. In 1938 fully 90 percent of the cultivated land was devoted to sorghums. But even the sorghums, which demand little moisture

FIGURE 35.—In 1937, this field (same as shown in fig. 34) grew 964 pounds of milo heads an acre and the rainfall was only about 75 percent of normal.

FIGURE 36.—Between 1925 and 1929 over 65 percent of the Hereford project area was broken from native sod for wheat.

in comparison with wheat or corn, frequently failed unless full advantage was taken to conserve the very limited rainfall.

Of the 28,765 acres farmed under agreement with the Soil Conservation Service, 11,225 acres are terraced and 12,797 additional acres are being farmed on the contour. Approximately 17,000 trees were growing on the project in 1938. Continuous dry weather, drifting sand, and jack rabbits are among the reasons for failure. However, 75 percent of the trees planted in 1935 survived, and 80 percent of those planted in 1936 survived.

Hereford Area, Tex.

The Service project, at Hereford, Tex., designated as Texas 11, received its name from nearby Hereford, the county seat of Deaf Smith County. And the county seat received its name from a breed of cattle which is almost as characteristic of the Plains as short grass, high winds, and limited rainfall.

Prior to 1925 Hereford cattle dominated the agricultural picture in this locality. Between 1925 and 1929 over 65 percent of the project area—31,728 acres in Deaf Smith, Parmer, and Castro Counties—was broken from native sod for wheat (fig. 36). In later years the wheat acreage was reduced about 8,000 acres in favor of sorghums, but wheat is the predominating crop under cultivation.

With the exception of lands that border on the three small streams within the project area, the surface appears almost flat. About 85 percent of the land

area slopes less than 1½ percent. The nearly flat surface is pitted by more than 20 small playa lake basins, which are approximately 10 to 20 feet deep and occupy areas ranging from 5 to 40 acres. These areas are dry except during and immediately after rainy seasons, as are also the three small streams that traverse the project area.

About 40 percent of the area has been damaged to a considerable extent by wind erosion. Several fields in the northwestern and southeastern portions were hummocked rather severely by accumulation of wind-drifted material. Drifts were prevalent along fences throughout the area. Perhaps the greatest damage occurred to the grassland, much of which was covered with wind-blown soil to depths ranging from 1 to 4 inches. This damage can be accounted for by the small ratio of grass in comparison with the cultivated land. The cultivated land, though largely devoted to wheat, had a good cover when rains were sufficient, but the series of dry years beginning in 1932 left most of the land unprotected.

Approximately 90 percent of the land consists of relatively deep, productive soil. The rest of the area is largely that of a shallow Plains soil. These soils have a medium to slow rate of infiltration, but a high moisture-holding capacity. If unchecked, a considerable quantity of water flows into the lake basins.

The large area of heavy soil is especially well-adapted to wheat, and sorghums do well also. Though the area is well-adapted to sorghums, this crop is incidental to wheat and can be more efficiently utilized by consumption on the farm through livestock than by direct marketing. But in the production of either wheat or sorghum little attempt has been made in the past to hold water and sink it into the soil. Surface water is sufficient, if saved, to greatly increase the dependability of crop production.

Control measures in this area, as elsewhere on the Plains, represent efforts to conserve rainfall for the benefit of vegetation. Contour farming and terracing have proved effective in conserving water on cultivated land, and nowhere have crops given a more robust response. Equally effective have been the water-saving and water-spreading methods used on the comparatively small acreage of range lands. In 1937 this area received a more favorable rainfall than many others on the Plains, but the treated land in the area responded with larger yields of grain, forage, and pasturage than did the untreated land.

Many examples could be cited; a few will suffice here. The crops shown in figure 37 were harvested in 1937. The field on the right produced only a little more than 2 bushels per acre, whereas 15 bushels were harvested on the field at the left. No conservation measures were applied on the field to the right. Weeds were permitted, in September 1936, to claim a large percent of the soil moisture. The field, across the road on the left, was contour-listed in the summer, and practically no weeds were permitted to grow. The wheat was drilled on the contour in late September.

In February 1936, a cooperator placed contour furrows in his 111-acre pasture.

He used a single-row lister and placed the furrows 84 inches apart. He was so well pleased with the results during the spring, summer, and fall of 1936 that additional furrows were made in March 1937. The entire pasture now has furrows 42 inches apart. The soil that was furrowed in 1936 was almost completely grassed over in two seasons, and the furrows newly constructed in 1937 were grassing over nicely by early summer 1938.

The good response of grass in this instance can be attributed in part to the generous rains that came in May 1937. But a part of the response can be attributed to the fact that the pasture was ready to take water. Prior to May 29,

FIGURE 37.—Water-conservation measures were used on the field to the left which yielded 15 bushels per acre in 1937. On the right, weeds and annual grasses robbed the wheat of moisture, and the yield was a little more than 2 bushels per acre.

1937, 3¾ inches of rain fell during that month. On May 29 an additional 2½ inches came down. A check revealed that the pasture held all of the water that fell. Moisture penetrated to an average depth of 42 inches.

It was observed in the spring of 1936 that much water was being carried in the bar ditch of the road to a lake. A diversion ditch was constructed to carry this water onto the pasture, where it was distributed over several acres by the small furrows. During the 1937 pasture-growing season the cooperator kept 28 head of livestock on this 111-acre pasture.

There are 60 farm units in this project area. By 1938, 51 farms, comprising 24,110 acres, were operating under an agreement with the Soil Conservation Service in the application of soil- and water-saving measures. Complete treatment as called for in the agreements was finished on 6,115 acres; 10,020 acres have been terraced, and 4,000 acres of range land have been contour-furrowed.

Memphis Area, Tex.

The westward advance of cotton across the South reached the southeastern corner of the Texas Panhandle in the early nineties (fig. 38). In 1891 a committee of businessmen in Memphis, in Hall County, 30 miles west from the Oklahoma line, distributed a ton of cottonseed among a few farmers for a trial planting. D. H. Davenport recalls that he received two sacks of seed, each sack holding about 1½ bushels. While plowing with his ox team, he carried seed along and dropped it in the furrow. But before the first sack was empty he threw the

FIGURE 38.—The westward advance of cotton across the South reached the Texas Panhandle in the early nineties.

other over the fence to a neighbor; one sack of seed was enough for a trial, he thought.

The initial trials of cotton by Mr. Davenport and others on land taken from the range proved fruitful. When more farmers came into the area the cotton acreage expanded. By 1907, when the first cotton gin was built, the crop had risen to 10,000 bales; 21 years later the peak was reached with 82,500 bales. From 1924 to 1933, inclusive, the average was 52,000 bales. From 1934 to 1937 the average dropped to 31,490 bales. The decline is attributed to droughts, soil erosion, and acreage reduction.

In general the rotation followed for 30 years has been cotton-cotton-cotton. Settlers coming from the Corn Belt tried corn rather persistently; others tried wheat. But neither corn nor wheat ever claimed any significant part of the

acreage as compared with cotton. The dairy industry, which came in during the early twenties, created a demand for forage and feed crops. The sorghums have served well to satisfy this limited demand. On the whole the business set-up of the area was keyed to cotton, and there has been little inducement to grow other crops extensively.

On these rolling Red Plains in the lower Panhandle people speak of the area as being under the cap rock. By the word "under" they really mean below and off the rock. The altitude is about 2,100 feet, whereas on most of the High Plains it is 3,500 feet or more. The low elevation, along with the southern latitude, provides a long growing season. The rainfall averages about 23 inches a year, and its distribution is far more favorable than in many other sections of the southern Plains.

Soil scientists classify the soil in this area as "deep, moderately sandy, and highly productive." These soils take water rather rapidly and have a good capacity for holding it once it is taken. Run-off is slow except after the heavier rains. Yet even with these advantages, pushing cottonfields up 6-, 7-, and 8-percent slopes brought soil troubles quickly. Cotton is a long-season intertilled crop, and since cover crops have been sparingly used a troublesome amount of soil has been lost in many fields that were thickly grassed 20, 25, or 30 years ago. On some of the more sloping land practically all of the topsoil has been lost. Many gullied fields have been retired to pasture, but the gullies which lie below unprotected uplands continue to widen and deepen.

G. A. Sager went to Hall County for his health in 1907. At that time Memphis was a sprawling frontier town. Sager recalls that he crossed a ditch near town with his team and wagon. When the front wheels of the wagon dropped in the ditch the rear wheels were still on the bank to the rear. And when the front wheels lifted to climb the opposite bank the rear wheels dropped into the ditch. This same ditch today is 200 feet wide. It is dry most of the time, but it carries a heavy load of soil after heavy rains.

Some of the earlier cotton growers noticed that cotton rows across the slope would occasionally break under the impact of water from heavy rains, and gullies would form. To meet this difficulty the rows for the following crop were run up and down the slope so "each row would carry its own water."

Still later some growers placed reliance upon terraces to check the downward rush of water. These early terraces, though frequently faulty in design and spacing, helped to save some soil. Yet even if the modern terrace had been used it is probable, in the light of present knowledge, that they could not have stood up against continuous cropping to cotton.

In this area one sees evidences of wind erosion. But the damage from the wind is very moderate compared with the general havoc caused by water through sheet erosion and gullying. Gullies, which always suggest an advanced stage of sheet

erosion, are occasionally etched so deeply that they are referred to as the two- and three-story kind (fig. 39).

Distress in this lower cotton Panhandle area is not so marked as it has been in many of the areas to the north on the high Plains since the early thirties. A comparatively reliable rainfall and a rich soil, along with large-scale farm machinery, have served, in spite of low cotton prices, to keep most farmers in the country and off relief rolls. Average yields for the area have held up well but, as in all new parts of the country, worn land has been traded for new.

C. C. C. boys under the direction of the Soil Conservation Service started their activities in this area in the fall of 1935. As is customary in most camps the work area is a circle of land within a radius of 25 miles from headquarters. The work area for this camp includes adjoining corners of Collingworth, Donnelly, Childress, and Hall Counties. The whole area, covering 1,200,000 acres of land, lies principally in the upper headwaters of the Red River.

Erosion-control measures on cultivated land in this area involve in the main a three-point program. The first problem was to induce growers to get away from the idea of planting a whole field to cotton with all rows running parallel irrespective of slope. Each cottonfield should be stripped on the contour with an erosion-resisting crop such as a sorghum or perhaps a small grain. These erosion-resisting strips should comprise approximately one-third of the field.

The second point stressed was to provide terraces to support and enhance the strip-cropping program. Terraces were not always needed. On some of the

FIGURE 39.—Uncontrolled water has etched some gullies so deeply that they are referred to as the two- and three-story kind.

more sandy soils contour tillage alone was adequate to prevent run-off of water. On land adapted to terracing the row-crop type was used. The height of this terrace is about 15 to 18 inches, and the width is about 30 to 35 feet. It meets the need of power-farming equipment which ranges in size up to four rows. While this equipment is large, it does not require as flat and broad a terrace as the large wheat equipment used on the high Plains.

The third point in the control program for cultivated land is the necessity to provide cover crops on land that would otherwise go through the winter unprotected. Rye is being grown successfully by some farmers for this purpose. It is sown between the cotton rows in the late fall and plowed down for a green-manure crop in the early spring. Wheat is also grown as a cover crop. It can be used for pasture during the fall and winter. In the spring it can be left to mature as a cash crop if it looks promising. If not, it can be plowed down and followed with cotton or sorghum.

There are still other devices in use for reducing soil losses in this area. Turn rows and point rows are planted to Sudan grass, sorghums, or a permanent grass. Listing or chiseling between rows of crop stubble or crop residue before the spring blow season is applicable in this area. If early rains come the soil is in condition to store water prior to the planting season. This practice should not, however, be confused with emergency listing which is resorted to after neglects and abuses have resulted in serious erosion conditions.

The program for erosion control on pastures is similar to that applied on other areas in the southern Plains. It involves controlled grazing, pasture furrowing, and weed eradication. Stock dams are built to provide watering places and to help distribute animals over the range. On rough, broken lands and escarpments, places where water cannot be used where it falls, spreading devices are used.

Looking to the future, the area is in distinct need of more livestock to consume the greater quantity of forage and feed which would naturally come through the greater production of crops resistant to soil erosion. This, however, does not mean that the area will produce less cotton. Tests at the Spur station indicate that yields from a rotation of cotton and sorghum are more per acre than the yields from cotton grown alone continuously.

During 3 years of operation in this camp area 164 farmers employed some form of soil-saving strategy for their land. By December 1938 there were 96,250 acres under agreement. Of these, control measures had been completed on 46,740. Terraces had been completed on 28,901 acres and controlled grazing was in effect on 55,363 acres.

Cherry Creek and Black Squirrel Creek Areas, Colo.

High up on the foothills of the Rockies, in the Pike's Peak section, lie two Service projects—Cherry Creek and Black Squirrel Creek (fig. 40). Cherry Creek flows northward into Denver, where it joins the South Platte. Black Squirrel Creek flows southward and joins the Arkansas east of Pueblo. The entire Cherry Creek demonstrational area—33,000 acres—lies entirely within the

Figure 40.—Two Colorado project areas lie high up on the foothills of the Rockies near Pike's Peak. Note how the contour furrows have impounded snow.

section known as the Black Forest. The upper headwaters of the Black Squirrel area—159,000 acres—rise in the southern portion of the same forest section. The two projects are but 7 miles apart.

The first rush for gold, up the draws of lower Cherry Creek near Denver, in the sixties was hardly more headlong than the rush of settlers to grow crops on the flatter slopes of this project area in the early part of the present century.

Many of the early crop farmers purchased (about 1890) sloping grasslands below that part of the Black Forest that is now covered with timber. Though these soils are shallow, acid, and moderately low in potential fertility, they produced good crops of potatoes in favorable years.

Much of the higher forested area had good cover prior to 1912. About this time a market developed for mine props, ties, and box lumber. As a result many parts of the forest were practically denuded of all except small reproductive seedlings. By grazing a comparatively large number of livestock on the areas

so opened by destructive logging, the normal development of the young seedlings was prevented. The protective carpet of litter which is normally present in a forest was destroyed. Surface run-off from rain and snow was greatly increased. Erosion was accelerated. With less moisture in the soil, the growth of timber was further retarded.

After the best of the timber was removed many cut-over tracts of 40 to 160 acres were sold to farmers. Prior to and during this time other farmers on the lower slopes were expanding their potato acreage. Their yields werc good and the community prospered. But the potato psylla struck the area, and the infestation increased so swiftly that practically every commercial potato grower was forced out of business. Abandoned potato cellars in many washed and gullied fields are about the only visible reminders today of the once-profitable potato industry. Potatoes had been grown long enough on the thin sloping soil to lay it open to the lash of rain and the rush of water.

The pinto bean, although grown for the most part on the more gentle slopes, accounts for much soil loss by wind and water. Bean growing on a large scale was attempted, in the main, after the World War and after farmers learned that wheat was an undependable cash crop. The bean acreage expansion was most intense in the lower two-thirds of the Black Squirrel Creek project area. Having no regard for soil type or potential productivity, many farmers plowed, planted, and harvested bean crops, let the land lie unprotected at the mercy of water and wind, and repeated the schedule until fertility was exhausted and abandonment was forced. The first of the bean growers, as was true with potato growers, raised bountiful crops in the favorable years. Several farmers from Kansas, Nebraska, and eastern Colorado bought quarter sections and raised as high as 1,200 pounds of beans an acre and paid for all of the land with a 40-acre crop.

But success with beans as with potatoes, when the land was comparatively new, lured another wave of farmers who purchased too few acres at too high a price. And, these later farmers, finding that much soil had already moved down the hills, tried to make a living and pay debts by increasing their livestock. As a consequence the livestock numbers were increased beyond the carrying capacity of the cramped holdings on the range.

Though these farmers from the Plains to the east had been accustomed to limited and erratic rainfall, when they moved to the higher and drier areas near the mountains they found that rainfall was still more limited and still more erratic. While the rainfall in this area is not much less than it is on the Plains, over 75 percent of the total comes in torrential downpours during the spring and summer months. Occasionally it will rain as much as 3 inches in an hour, with most of it slashing down in the first 20 to 30 minutes.

Early-day cattlemen and miners report that floodwaters rushed down these slopes with incredible speed even before farmers came in with their axes and

FIGURE 41.—This picture, taken in 1884, of the town site of Elizabeth, Colo., indicates that vegetation prevented serious erosion by floods in Box Elder Creek (see fig. 42).

FIGURE 42.—Elizabeth, Colo., and Box Elder Creek as it appeared in July 1935. The creek bed is more than 200 feet wide.

plows to destroy the vegetal cover. But none of these early reports of flood damage compares in scope and disaster with those of more recent years, when continuous tillage, excessive grazing, and drought have further depleted the natural cover (figs. 41 and 42).

One of the most damaging floods in recent years occurred on Memorial Day, 1935, when 14 lives were lost in, and adjacent to, these areas. In the town of Elbert, which lies in an adjoining drainage to the east of Cherry Creek, 60 of the 150 houses were washed away. The Colorado & Southern Railroad in this vicinity was completely abandoned after this flood.

When the Soil Conservation Service established projects in this area farmers and others hoped that something could be done to check the rush of floodwater which tumbles and plunges down the steep slopes, endangering lives and destroying property in the lowlands. This was only part of the problem. Equally important was the problem of developing safeguards that would protect soil and crops so that farmers could live on the land.

Soil surveyors estimated that at least 60 percent of the Cherry Creek and between 70 and 80 percent of the Black Squirrel Creek areas was in grazing land. Some of this was forest grazing land of little value, and outside the forest area were thousands of acres that were practically devoid of any vegetation. The first problem, it seemed, was to hold as much water as possible on the upland ranges and provide a safe escape for the excess. This called for deep furrows with high ridges. While these capacious structures have held the water miraculously well and the flood hazard has been reduced, later trials with shallower and more closely spaced furrows have shown better results in grass improvement. Water-retention structures of this type, technicians say, help to spread the water over the land where grass roots can more easily get to it.

In general, all the devices to improve ranges that have been mentioned on previous pages, have been used by cooperating farmers on these sloping Colorado projects (fig. 43). While the grassland has made a hopeful response to treatment, there can be no adequate solution to the problem until livestock numbers are reduced. Most of the farmers, as in many other areas on the Plains, need more land than they have at the present time.

Under the pressure to hang on and make a living many farmers in the area still grow a few potatoes, some beans, some corn for silage, and some wheat, barley, and oats. The corn, beans, and potatoes are all intertilled crops and present a hazard in holding soil. Bean land in particular, blows like flour in a high wind or is easily carried away if it rains. The wheat, oats, barley, and occasional fields of rye help to hold some soil. Rotations of crops, which include a blend of legumes or grasses along with the small grains and intertilled crops, have been practiced sparingly in the area. The absence of crop rotations can be explained in part by the limited choice of adaptable crops. In this high altitude (between 6,000 and 7,500 feet) the growing days during the season usually vary between 100 and 110.

Although the sorghums are not so well-adapted as they are in the adjacent flatter and lower areas to the east and south, they are a fair choice in this section where any crop is hazardous. Effort is now being made to find sorghum varieties that are better adapted to the soil and climate, and hope that they may be found is heightened by the favorable results of recent trials by farmers and experiment stations on the northern Plains.

Bromegrass, western wheatgrass, and a few other grasses are proving very satisfactory on demonstration farms, and particularly in the Cherry Creek area. The production of bromegrass for seed is giving satisfactory cash returns as compared with those from grain crops. From the standpoint of erosion control

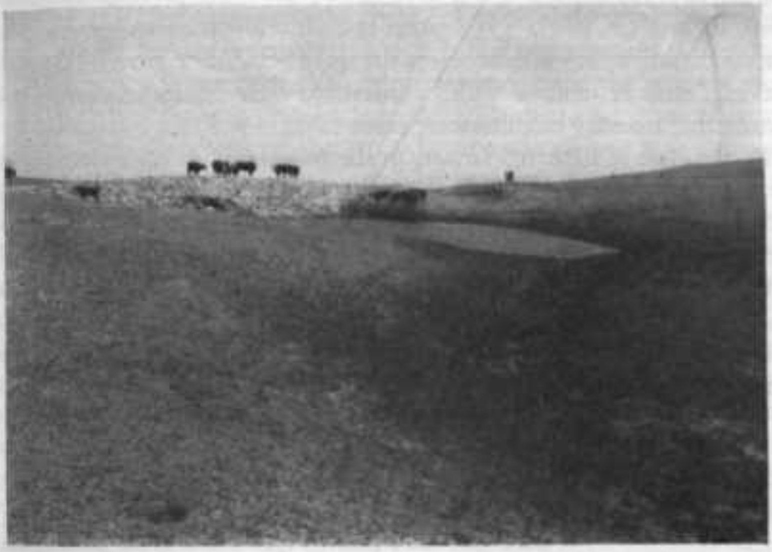

FIGURE 43.—A stock pond of the type constructed to provide water and spread livestock on the range.

the small-grain crops are giving good results in this area. On the Black Squirrel area millet and winter rye are used in the cropping program. These crops provide both feed and cover.

Apart from the choice of crops, the control measures applied by cooperating farmers on their cultivated land represent, in the main, the same principles as are being used elsewhere in demonstration areas. Practically all crops are planted on the contour, and these crops are worked into various strip-cropping patterns. Strips of corn or beans are protected by strips of millet, wheat, barley, oats, rye, or in some cases by buffer strips of perennial grasses.

Some of the cultivated fields have been terraced. But terracing, a relatively expensive operation, has been confined to those fields where there is still some topsoil that can be saved and where the slopes are not excessive. The type of

terrace used on this high land, near the roof of the continent, has undergone considerable adaptation as compared with the broad-base low-crown wheatland terrace of the Plains. In general the base is much narrower and the crown is much higher than those of the wheatland terrace. This altered design, farmers feel, is better adapted to the natural conditions at hand. Some of the terraces have been given a very slight grade. With this type of construction water does not stand long enough to drown the crops. Terraces with grades, however, are provided with outlets that conduct the water safely down the slope.

Here as elsewhere farmers have made objections to the cultivation of point rows. Partly to meet this objection and partly to protect terrace ridges, conservationists have recommended, and some farmers are using, permanent vegetation on the terrace ridges, and this vegetation extends below the terrace embankment far enough to take up any unevenness in the space between terraces. This procedure leaves a strip of uniform width adjacent to each terrace channel, thus eliminating the necessity of cultivating point rows.

By the close of 1938, 105 farmers in the two areas had applied erosion-control practices on their land. The total cropland was reduced from 12,275 to 9,194 acres. On this cropland, strip cropping in its various forms had been applied on 5,807 acres, terracing on 2,115 acres, and approved rotations on 8,964 acres.

On range lands contour furrows and ridges were constructed on 28,888 acres, and 245 stock ponds were built. Trees and shrubs numbering 1,492,074 were planted for wood-lot improvement, gully control, protection of dams and ditches, windbreaks, and cover for wildlife.

Cooperative Action Through Conservation Districts

Significant as the results on the project and camp areas may appear in the control of erosion, the combined acreage in these demonstrations is only about 1 percent of Region 6. While these demonstrations may point the way the most pressing problem is to bring about the adoption of better practices on the much larger areas of land that surround the demonstrations. The problem, in its general aspect, cannot be solved if only a few farmers adopt the appropriate practices. The treated fields and farms benefit temporarily from soil- and water-conserving measures. But if neighboring fields are unprotected the soil will blow or wash onto the treated land.

Early in 1936 the Department of Agriculture concluded that sufficient progress in erosion control could not be obtained unless it became possible to treat whole bodies of land. In seeking a democratic method whereby landowners and operators could spread the use of control methods, the Department suggested that the States pass enabling acts, thus making it possible for interested farmers to establish soil conservation districts. (See Soil Conservation Districts for Erosion Control, U. S. Dept. Agr., Misc. Pub. No. 293.)

Through these districts farmers and ranchers are authorized to exercise cooperatively their own initiative and responsibility in combating soil erosion. If it is necessary to prevent misuse of land, they may vote land use regulations for themselves.

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